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ABSTRACT

This report presents information from phase I of a survey designed to develop quantitative indicators of the current national stock, cost/investment, condition, obsolescence, utilization, and need for major research instruments in academic settings. Data for phase I (which focused on the physical and computer sciences and engineering) were obtained from department heads and from faculty scientists and engineers at a stratified probability sample of 43 universities (excluding federally-funded research development centers). These data are discussed and analyzed in a final section with respect to six major topic areas: (1) department heads' assessments of instrumentation needs and priorities; (2) amounts and costs of research equipment in the 1982 national stock; (3) instrumentation age and condition; (4) funding patterns; (5) instrumentation location and usage; and (6) instrumentation maintenance and repair. Technical notes, questionnaire used, detailed statistical tables, and other information are provided in appendices. Among the findings noted are those indicating that research personnel cannot conduct critical experiments in important subject areas due to lack of equipment and that the top priority need is for upgrading and expanding equipment in the $10,000 to $1,000,000 range. (JN)

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ACADEMIC RESEARCH EQUIPMENT IN THE PHYSICAL AND COMPUTER SCIENCES AND ENGINEERING

An Analysis of Findings from Phase I of the National Science Foundation's National Survey of Academic Research Instruments and Instrumentation Needs

Prepared for:

Universities and Nonprofit Institutions Studies Group
Division of Science Resources Studies
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Contractor staff who played significant roles in the survey and in the preparation of this report were:

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In addition to the NSF and Westat project staff, two advisory groups contributed significantly to the project. The first, the Interagency Working Group on University Research Equipment convened by NSF, played important roles in reviewing project feasibility study results and in providing NSF with recommendations about key features of the research design. Secondly, the project's Phase I Advisory Group made many valuable contributions both in the refinement of the research design and in the assessment of Phase I findings. The members of these two groups are listed in Appendices C and D.

This report presents information from Phase I of the baseline cycle of the National Science Foundation's (NSF's) National Survey of Academic Research Instruments and Instrumentation Needs. The data were collected in early 1983 from department heads and from faculty scientists and engineers at a stratified probability sample of 43 universities selected from the 157 largest academic research and development (R&D) performers, excluding medical schools and Federally-funded R&D Centers. In each sampled department, inventory lists containing information on each piece of scientific and engineering equipment were examined. Nearly 5,000 equipment items were selected in the Phase I survey, producing nationally representative baseline indicators of instrumentation needs and of the amount, condition, cost, and usage of the existing national stock of academic research instruments in three selected fields — the physical and computer sciences and engineering. The second phase of the baseline survey, involving the agricultural, biological and environmental sciences, was conducted in 1984 and will be presented in a later report. The survey was limited to instrument systems costing $10,000 to $1,000,000.

EXECUTIVE SUMMARY

- The NSF's National Survey of Academic Research Instruments and Instrumentation Needs received near-universal support among respondents. Although substantial time and effort were required to provide the many survey lists, forms and questionnaires, each of the 43 universities in the original study sample participated fully in the research, and only seven of over 4,000 originally sampled research instruments were unaccounted for as a result of researcher refusal to provide the requested data. In and of itself, this extraordinary level of response is a significant indicator of the extent of concern that exists throughout the academic community about the adequacy of the current stock of research equipment.

- This concern, implicit in the study's high response rates, was expressed explicitly in the survey of heads of research departments and facilities in the physical and computer sciences and engineering.

- Over half (52%) of the department heads in these fields characterized the research instrumentation presently available to untenured faculty as typically "insufficient;" about as many (46%) so-characterized the equipment available to tenured researchers.

- 90 percent of the department heads surveyed reported that, as a result of lack of needed equipment, there are presently important subject areas in which their research personnel cannot conduct critical experiments. This level of concern was found in all fields and subfields and in all types of universities studied.

- According to 90 percent of the department heads surveyed, the top priority need is for upgrading and expansion of research equipment in the $10,000 to $1,000,000 range.

AMOUNT AND CONDITION OF EXISTING EQUIPMENT

- Many of the quantitative findings appear to be consistent with department heads' qualitative assessments of current instrumentation inadequacies. For example, the estimated original purchase cost of the entire 1982 national stock of all $10,000 to $1,000,000 academic research equipment that has been accumulated in the physical and

computer sciences and engineering is $1 billion. In functional terms, the 1982 national stock is smaller than that, since one in every four research instrument systems physically present in 1982 had been completely inactive for at least a full year and was technologically and/or mechanically obsolete.

- At the other end of the spectrum, only 16 percent of the systems in the 1982 national stock in the fields surveyed were classified as state-of-the-art.

- One-half of all research instrument systems was purchased within the previous 5 years; one-fifth was 6 to 10 years old; and the remaining three-tenths was 10 or more years old.

- For the bulk of the equipment in research use in 1982, that which was not state-of-the-art, over half (58%) was in less than excellent working condition. One-half (49%) of the equipment classified as not state-of-the-art was the most advanced equipment to which the research users had access, indicating that investigators do not have access to more advanced equipment.

FUNDING

- Two-thirds of all in-use research equipment (68%) were acquired partly or entirely with Federal funding support. The NSF was the principal source of Federal instrumentation support, accounting for 27% of the aggregate acquisition cost of all in-use research equipment in the fields surveyed. The Department of Defense (DOD) was also a major source of instrumentation funding, accounting for an overall 14% of all instrumentation support in Phase I fields and for a substantial 22% of engineering instrumentation support.

- As of the end of 1982, recently-enacted Federal tax incentives aimed at increasing industrial donations of research equipment to colleges and universities had not yet had much of an impact. Only 1% of the in-use academic research equipment in the fields surveyed had been donated used, and only 2% had been donated new. Most in-use equipment (84%) had been purchased new, off the shelf.

MAINTENANCE AND REPAIR

- On the average, departments spent $50,000, or 16 percent of their instrumentation-related expenditures, for maintenance and repair (M/R) of research equipment in FY 1982.

- Most research departments (94%) in the physical sciences and engineering operated or had access to on-campus machine shops or other facilities for M/R of their research equipment. However, only 6% of the departments in these fields assessed their M/R facilities as excellent, and these departments spent almost twice as much, $88,800 per department, for M/R of research equipment in FY 1982 as the overall average of $50,000 across all departments.

- Service contracts constituted the most common form of maintenance and repair of research equipment in computer science: 49% of all in-use systems in this field were maintained principally through service contracts in 1982. By contrast, on-campus M/R and research personnel were the principal sources of M/R for equipment in the physical sciences and engineering, where 47-49% of all in-use research systems were maintained principally by in-house staff.

UTILIZATION

Since the supply of equipment needed for frontier research is limited, it is important that the equipment which does exist be well utilized. Insofar as one can judge from the mass of survey statistics pertaining to location and usage, it appears that conscientious efforts are being made to achieve widespread, equitable sharing of available research equipment.

- Nearly half (45%) of all in-use research equipment in the 1982 national stock was located in inherently shared-access facilities — department-managed common labs, national and regional labs, etc.

- Although a substantial fraction (35%) of the equipment in Phase I fields was not amenable to widespread usage (being dedicated for use in a particular experiment) and although much of this dedicated equipment was located in within-department labs of individual investigators, the mean annual number of research users of instruments located in such labs was 8.9 in 1982, a figure hardly suggestive of restricted access.

- The mean annual number of users of research instrument systems that were located in inherently shared-access facilities was 28.9 users per system in 1982.

- Particularly for comparatively high cost instruments, there was considerable evidence of routine sharing of equipment beyond the confines of the host department or facility — sharing with faculty and students from other departments and even with those from other universities or from non-academic settings.

INTRODUCTION

BACKGROUND

Recent advances in microcircuitry and other fields have led to the development of new generations of research instruments with capabilities vastly more powerful than those available 10 or 15 years ago. As measurement tools have become increasingly complex and powerful, however, they have also become increasingly expensive. During the past decade, as instrumentation costs progressively increased, many of the nation's colleges and universities experienced severe fiscal problems reducing their ability to fund new acquisitions.

The cumulative effects of these trends on academic research are difficult to assess. A 1980 survey of investigators at 16 leading research universities reported numerous instances where scientists felt that, because of a lack of needed instrumentation, they were no longer able — or were on the verge of being no longer able — to work at the frontier of research in their respective fields.[1] However, the evidence to date has been almost entirely anecdotal.

In recognition of the need for "objective information in the area," the House Committee on Science and Technology recommended that the National Science Foundation "conduct inventories of, and analyses of the needs for, scientific instrumentation."[2] The resulting legislation, when enacted and signed into law, directed the Foundation to "develop indices, correlates or other suitable measures or indicators of the status of scientific instrumentation in the United States and of the current and projected need for scientific and technological instrumentation."[3] In

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[1] Association of American Universities. The Scientific Instrumentation Needs of Research Universities, Report to NSF, 1980.

[2] House of Representative Report No. 96-61 (1979), p. 30.

[3] An Act to Authorize Appropriations for Activities for the National Science Foundation for Fiscal Year 1980, and for Other Purposes. Public Law 96-44, Section 7.

response to this mandate, the Foundation initiated a feasibility study in FY 1980 to: (a) design quantitative indicators of current status and trends in the stock, condition, utilization and needs for research instrumentation in academic settings, and (b) assess the availability of this information and determine the most appropriate data sources and methods of data collection.

The feasibility study, conducted by Westat, Inc. in Fall 1981 at a national sample of 33 colleges and universities, concluded that it was feasible to obtain reliable quantitative indicators of current status and trends in academic research instrumentation. The feasibility study final report presented recommendations concerning proposed data collection methodologies and statistical indicators to be constructed from the resulting data.[4] Final specifications for the baseline national survey were developed by NSF following extensive review of the feasibility study findings by other Federal agencies and by university scientists and research administrators.

THE BASELINE SURVEY

The NSF baseline instrumentation survey, as it has come to be known, calls for the development of quantitative indicators of the current national stock, cost/investment, condition, obsolescence, utilization and need for major research instruments in academic settings.

The baseline survey was conducted in two stages, or phases. Phase I, conducted during the 1982-83 academic year at a stratified probability sample of 43 universities (excluding Federally-funded R&D Centers), concerns existing academic research instruments and instrumentation needs in the physical and computer sciences and engineering. Phase II, conducted during the 1983-84 academic year, completed the cycle by collecting data for the agricultural, biological, and environmental sciences. The same universities that participated in Phase I were asked to contribute

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[4] Indicators of Scientific Research Instrumentation in Academic Institutions: A Feasibility Study. Westat, Inc., March 1982.

to Phase II as well, together with a separately drawn sample of 24 medical schools, needed to provide a comprehensive picture of academic instrumentation in the biological sciences.[5]

In each Phase, two kinds of data were collected. First, all departments and nondepartmental research facilities in applicable fields were asked to provide information about the department or facility as a whole, particularly regarding research equipment costs and needs. Second, from equipment listings supplied by the university (sometimes with assistance from the involved departments), a sample of research instrument systems was selected from each department and facility, and the principal investigator (or other knowledgeable individual) was asked to provide information about the instrument's cost, age, condition, usage, etc. These latter data were used to construct quantitative statistical indicators of the cost, condition, etc. of the national stock of existing academic research instruments in the fields surveyed. Until very recently, it would not have been feasible to obtain the kinds of equipment lists required for the selection of such instrument samples. Most of the computerized university property inventory systems that were so useful in generating sampling lists for the study came into being or were substantially upgraded within the past one to three years.

The equipment survey component of each Phase was restricted to instrument systems with an original purchase cost of $10,000 to $1,000,000. Systems above this range are generally well-known throughout the research and policymaking communities and are individually subject to ongoing policy analysis. The selection of the $10,000 lower limit was based partly on the feasibility study findings that, while only 10 to 15 percent of the instruments over $500 in labs of individual principal investigators cost $10,000 or more, such instruments accounted for over 80 percent of the aggregate cost of all $500+ instruments. Also, it was the consensus of the NSF Interagency Working Group advisors that individual pieces of equipment below $10,000 are seldom of critical importance in determining whether an academic scientist or engineer is able to pursue his or her research interests.

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[5]Funding support for the medical school component of the Phase II data collection was provided by the National Institutes of Health.

The response to the Phase I data collection was truly extraordinary. All 43 sampled universities agreed to participate in the survey. All 348 applicable departments and other research facilities at sampled universities provided at least partial data to the study. Of an initial sample of 4,648 individual items of research equipment in these departments and facilities, outright refusals to provide requested information were obtained for only 7 items (0.1%). This remarkable response suggests that the subject of the survey, the adequacy of university research equipment, is a matter of near-universal interest and concern throughout the academic community.

THIS REPORT

This analysis of data from the first Phase of the baseline cycle of the NSF instrumentation survey has two principal objectives: (a) to construct and examine a variety of quantitative statistical indicators of major characteristics of the current national stock of academic research equipment in several fields, and (b) to document differences among research fields and among types of institutions in these indicators. In the following sections, Phase I findings are highlighted with respect to six major topics:

1. Department heads' assessments of instrumentation needs and priorities;
2. The amounts and costs of research equipment in the 1982 national stock;
3. Instrumentation age and condition;
4. Funding patterns;
5. Instrumentation location and usage; and
6. Instrumentation maintenance and repair.

The final section contains a brief summary of the Phase I findings. Further information about the survey design, response rate, and analysis procedures — including definitions of key analysis variables — is presented in Appendix A (Technical Notes). The detailed statistical tables, which provide the basis for the following discussion, are presented in Appendix B.

RESULTS

NEEDS AND PRIORITIES

HIGHLIGHTS

- 90% of department heads in the physical and computer sciences and engineering indicated that there were investigators who were unable to perform critical experiments in their areas of research because they lacked needed equipment.
- 52% of departments and facilities characterized the research instrumentation available to untenured faculty and principal investigators as "insufficient." Only 7% characterized their equipment status as "excellent." The situation was only marginally better for tenured faculty and equivalent principal investigators.
- Such instrumentation concerns were nearly as widespread among the largest research departments as among the many smaller, less well-funded departments.
- The most common recommendation (53% of department/facility heads) concerning instrumentation needs and priorities was for Federally-assisted upgrading and expansion of equipment in the $10,000 to $50,000 range.
- Another very frequent, top priority recommendation was for increased Federal investment in major shared-access instrument systems in the $50,000 to $1,000,000 range (36% of department/facility heads).
- Few department heads identified, as their top priority need, large-scale regional and national facilities (3%) or general enhancement of equipment and supplies in the labs of individual principal investigators (10%).

DISCUSSION

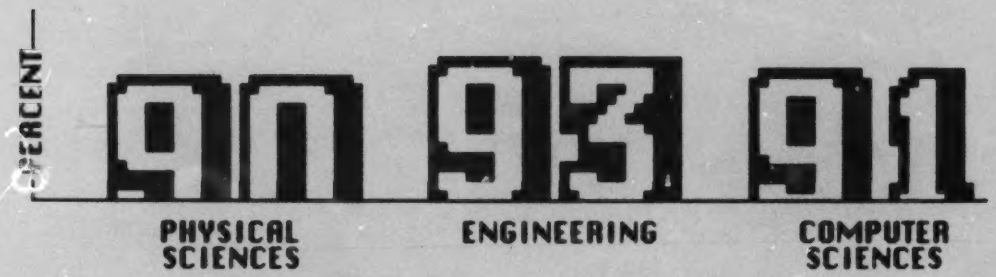
The heads of research departments and facilities in the physical and computer sciences and engineering were asked their views about the adequacy of existing research equipment and about their equipment needs. Their responses were essentially opinions, and as such, were similar in nature to the many earlier anecdotal reports that have appeared on this general topic. The difference was that the data

discussed below accurately represent the views of a large, statistically representative cross-section of a well-defined population (i.e., heads of departments and research facilities in the physical and computer sciences and engineering at the 157 largest — and presumably best equipped — research universities in the nation), not just the opinions of individual spokespersons or instrumentation advocates.

Limitations Imposed by Lack of Equipment

The first of three broad opinion questions asked whether there were "any important subject areas in which investigators in the department/facility were unable to perform critical experiments in their areas of research interest because of a lack of needed equipment." On this issue, there was very little difference of opinion (see Figure 1). Overall, 90 percent of department and research facility heads replied in the affirmative, and that was the response (plus or minus 5%) for each individual field and subfield, for each type of university, and for each department size category (see Appendix Table B-1). These findings support and reinforce earlier anecdotal reports.

Figure 1. Percent of departments reporting inability to conduct critical experiments due to lack of needed equipment, 1982

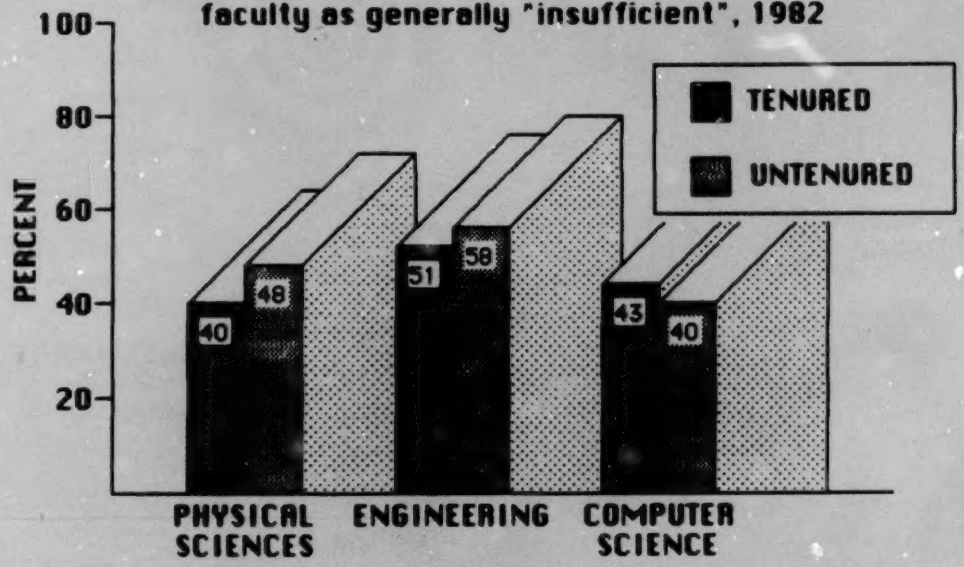


Reference: Appendix Table B-1

Adequacy of Research Equipment

The second opinion question inquired: "in terms of its capability to enable investigators to pursue their major research interests, is the research equipment in this department generally excellent, adequate or insufficient?" Department/facility heads were asked to respond separately for equipment available to tenured faculty (and equivalent principal investigators) and for that available to untenured faculty (and equivalent principal investigators). Overall, slightly more than half of the department/facility heads characterized the research equipment available to untenured investigators as insufficient (52%); only seven percent described it as excellent (see Appendix Table B-2). Computer science had the smallest percentage of departments with reportedly insufficient equipment for untenured staff (40%), the physical sciences were next (48%), and engineering had the largest percentage (50%). In four of the five major fields of engineering research, the insufficient percentages were considerably higher — in the 65 to 74 percent range. Civil engineering was the exception; in that field, only 48 percent of department heads considered the equipment available to untenured staff to be insufficient.

Figure 2. Percent of departments assessing the research equipment available to tenured and untenured faculty as generally "insufficient", 1982

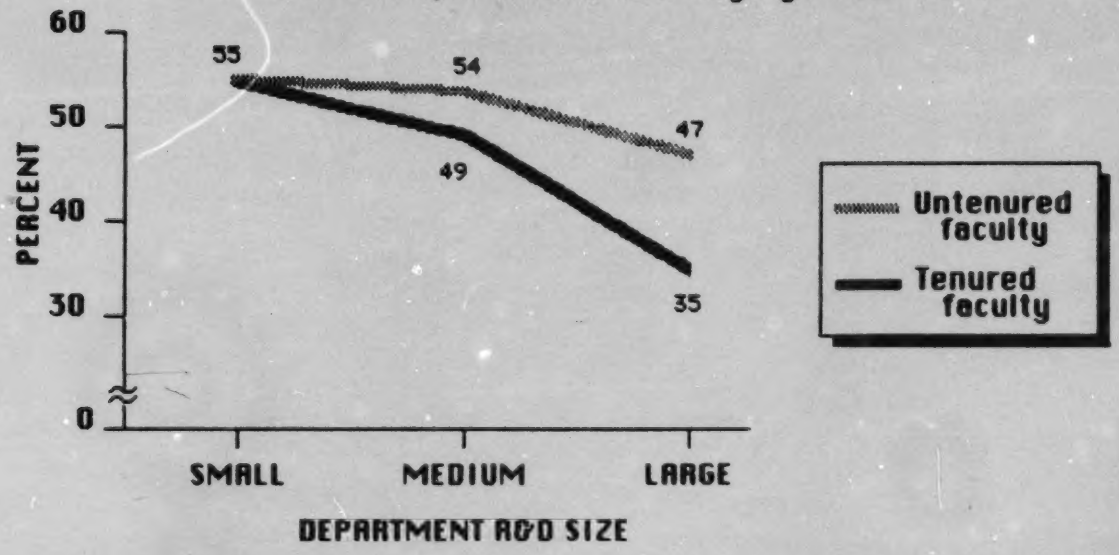


Reference: Appendix Table B-2

Findings for established, tenured investigators were much the same as for untenured researchers, except that the percent of department heads characterizing the instrumentation situation as insufficient was consistently a few points lower with reference to tenured researchers in two of the three major fields studied (see Figure 2). Even with regard to their senior scientists, however, a slight majority of heads of engineering departments (51%) described their research instrumentation as insufficient.

At the smaller R&D institutions and at departments with the smallest R&D budgets, there was essentially no difference between tenured and untenured staff in the assessed adequacy of the instrumentation available to them (e.g., in both staff categories, insufficient instrumentation was reported by 55% of the heads of departments and facilities with FY 1982 R&D expenditures under $50,000). At the largest R&D institutions and departments, the situation appears less bleak, but only for the established, tenured researchers (e.g., at the largest private universities, insufficient instrumentation for untenured staff was reported 46 percent of the time, but insufficient instrumentation for tenured researchers was reported by only 28 percent of these same departments). See Figure 3. Even in the most extreme cases,

Figure 3. Percent of departments/facilities rating available research instrumentation as inadequate, by R&D size of department and category of research



Reference: Appendix Table B-2

however, the situation was hardly reassuring; at departments with the largest R&D budgets, the most senior researchers were described as having excellent instrumentation only 10 percent of the time.

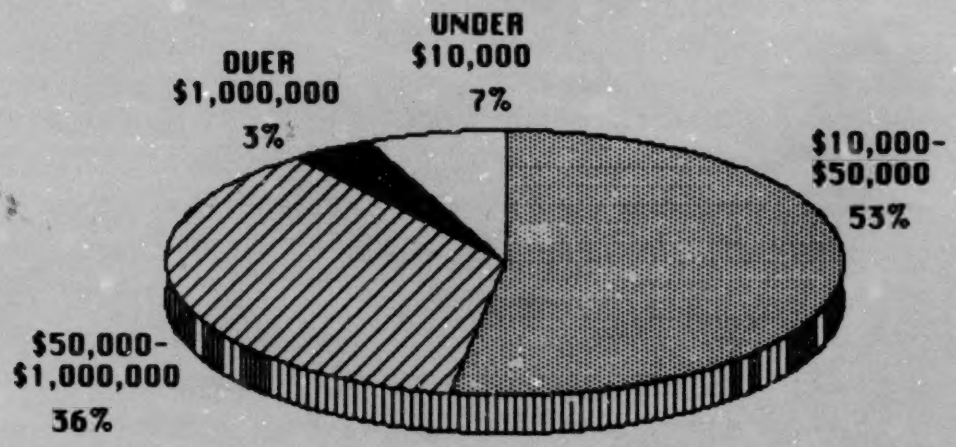
Priority of Various Types of Equipment Enhancement

The third opinion issue concerned department heads' recommendation as to the instrumentation area in which increased Federal investment would be "most beneficial to investigators in this department/facility." One choice, "large scale regional and national facilities (large telescopes, reactors, oceanographic vessels, high performance computers, etc.)," was the top priority recommendation of a few department heads in physics/astronomy (8%) and in electrical engineering (11%). This choice was not generally popular, however. Overall, only three percent of department and facility heads gave this recommendation (see Appendix Table B-3).

At the other extreme, "general enhancement of equipment and supplies in labs of individual principal investigators (items generally below $10,000)," was also unpopular. It was selected as the top priority recommendation by only seven percent of department heads overall. Chemical engineering was the only field in which this recommendation occurred with any regularity (21% of department heads).

In validation of the views of NSF's project advisors who recommended that the study be focused on equipment in the $10,000 to $1,000,000 range, this was the area of top priority need for 90 percent of the departments and facilities in the fields surveyed. Within this range, responses were split between departments/facilities that had the greatest need for "upgrading/expansion of equipment in the $10,000 - $50,000 range" (53%) and those whose greatest need was for: "major shared-access instrument systems ($50,000 - $1,000,000) not presently available to department/facility members" (36%). (See Figure 4.) In some fields, particularly civil, chemical, and mechanical engineering and computer science — and in the smaller R&D departments and institutions — the predominant need was for greater funding of equipment in the $10,000 to $50,000 range (see Appendix Table B-3). However, in other fields and in the larger departments and universities, there was also a substantial need for more costly equipment.

Figure 4. Department/facility top priority recommendation for increased Federal support of academic research equipment



Reference : Appendix Table B-3

The above findings are consistent with previously-reported, anecdotal evidence. They suggest that, at the department level, concerns about inadequate instrumentation were of significant proportions. In all of the research fields surveyed, the belief was so widespread as to be essentially universal that instrumentation inadequacies have already reached the point of impairing academic scientists' abilities to work competitively at the frontiers of scientific knowledge. Two particularly disturbing aspects of the findings were: (1) instrumentation concerns were nearly as widespread among the very largest and most prestigious research departments and institutions in the nation as they were among the many smaller departments and universities; and (2) the principal need appeared to be for instruments of substantial unit cost — $10,000 and above. Both factors suggested that the alleviation of current instrumentation problems — as seen from the perspective of department heads in the physical and computer sciences and engineering — will require a considerable increase in funding support.

SIZE OF NATIONAL INVENTORY

HIGHLIGHTS

- An estimated $230 million was invested in nonexpendable academic research equipment (with unit cost of $500 or more) in FY 1982. This amounted to $10,000 per faculty-level researcher.

- Department and facility heads projected an aggregate FY 1983 instrumentation investment of $264 million, a 16 percent increase over FY 1982.

- Mean FY 1982 research equipment expenditures per faculty researcher were highest at large private universities ($16,000 per faculty researcher) and lowest at small public universities ($8,000 per faculty researcher).

- In addition to direct outlays for purchase of research equipment, academic institutions spent an estimated additional $60 million for maintenance and repair of existing research equipment and $85 million for purchase of research-related computer services in the fields surveyed.

- At the end of 1982, the national stock of academic research instrument systems in the physical and computer sciences and engineering was estimated to have consisted of approximately 25,000 instrument systems in the $10,000 to $1,000,000 range, with an aggregate purchase cost of $1 billion.

- Not counting Federally-funded R&D Centers, an additional 40 to 50 "super-systems" with unit costs over $1 million were estimated to exist in academic settings, with an aggregate cost of $250 million. Although details about these multi-million dollar systems were beyond the scope of this research it was determined that most were used for research either in high energy physics or in astronomy.

- The 38 top R&D universities, which accounted for about half of all academic R&D expenditures annually, also were estimated to contain about half of all existing academic research instrument systems in the $10,000 to $1,000,000 range.

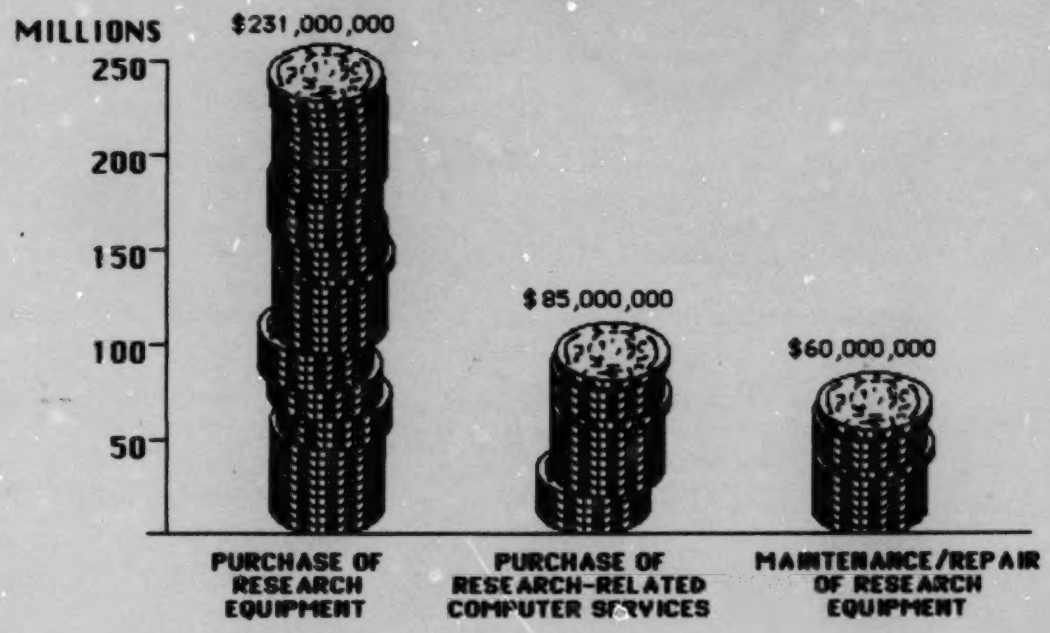
DISCUSSION

This section presents survey findings concerning (a) department heads' current and projected annual levels of investment in nonexpendable research equipment as of December 1982; and (b) the accumulated amount and cost of all $10,000 to $1,000,000 research instrument systems physically present in academic settings as of December 1982.

1982-83 Annual Investments into Research Equipment

In the fields surveyed, an estimated $230 million was invested in FY 1982 in research equipment costing $500 and over. (See Appendix Table B-12.) For the same fields, it was estimated that an additional $85 million was spent to purchase research-related computer services, and $60 million was spent in the maintenance and repair of research equipment (see Figure 5).

Figure 5. Instrumentation-related expenditures in academic departments and facilities, FY 1982



Reference: Appendix Table B-12

In addition to looking at the total expenditures for research equipment, estimates for anticipated FY 1983 purchases of research equipment $500 or more were obtained. While the actual FY 1982 expenditures were $231 million, the totals for the fields surveyed were anticipated to be over $264 million for FY 1983. This amounted to a 16 percent change in the annual expenditures between FY 1982 and FY 1983. (See Appendix Table B-13.) The field with the largest projected increase by far was computer science, which anticipated a 77 percent increase from the FY 1982 level. Engineering anticipated a 13 percent change between FY 1982 to FY 1983, while the physical sciences anticipated a 9 percent change. Projections did not vary by type of university. These "new" projections were not adjusted for the effects of inflation.

The 1,200 research departments and facilities in the physical and computer sciences and engineering at institutions in the survey universe can be divided into three approximately equal "size" classes, based on aggregate FY 1982 purchases of research equipment: those purchasing under $50,000 (32% of all Phase I departments and facilities); those purchasing $50,000 - $199,999 (34%); and those purchasing $200,000 or more (34%). As one would perhaps expect, most departments at large private universities (62%) were in the top third in equipment purchases; few departments at smaller public universities (23%) were in this size class; and other institution types were intermediate (see Appendix Table B-14.)

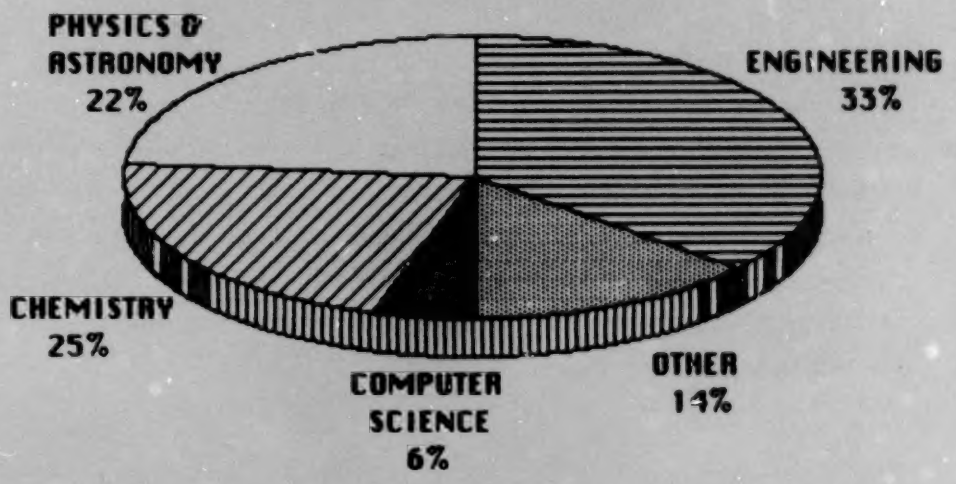
In FY 1982, total instrumentation purchases amounted to $10,000 per faculty-level investigator in the fields surveyed. Per investigator, computer science spent the most for research equipment, and engineering spent the least ($11,700 and $7,600, respectively.) The average amount spent per investigator in the physical sciences was $10,600. Within major fields of engineering, there was quite a range in mean FY 1982 equipment expenditures per investigator, with electrical engineering spending most ($16,600 per investigator) and mechanical engineering spending the least ($4,100). (See Appendix Table B-15.)

Magnitude of the 1982 National Stock of Instruments

The foregoing discussion concerned annual expenditures for nonexpendable research equipment in the $500 to $1,000,000 range, as determined from the department/facility survey. The remainder of this section presents findings obtained from the survey of $10,000 to $1,000,000 instruments concerning the magnitude of the 1982 national stock of academic research instruments in the physical and computer sciences and engineering. In these fields, there was an estimated total of 25,000 research systems in existence at the end of 1982. The aggregate purchase cost of these systems was approximately $1 billion.

In examining the data by field of research, the physical sciences had the largest dollar amount of research equipment (57% of the total), with an aggregate purchase cost of $464 million (see Figure 6). The total cost of systems in the field of engineering was almost $331 million, and computer science was markedly lower with $58 million. (See Appendix Table B-4.)

Figure 6. Distribution of aggregate purchase cost of academic research instrument systems in Phase I fields



Reference: Appendix Table B-4

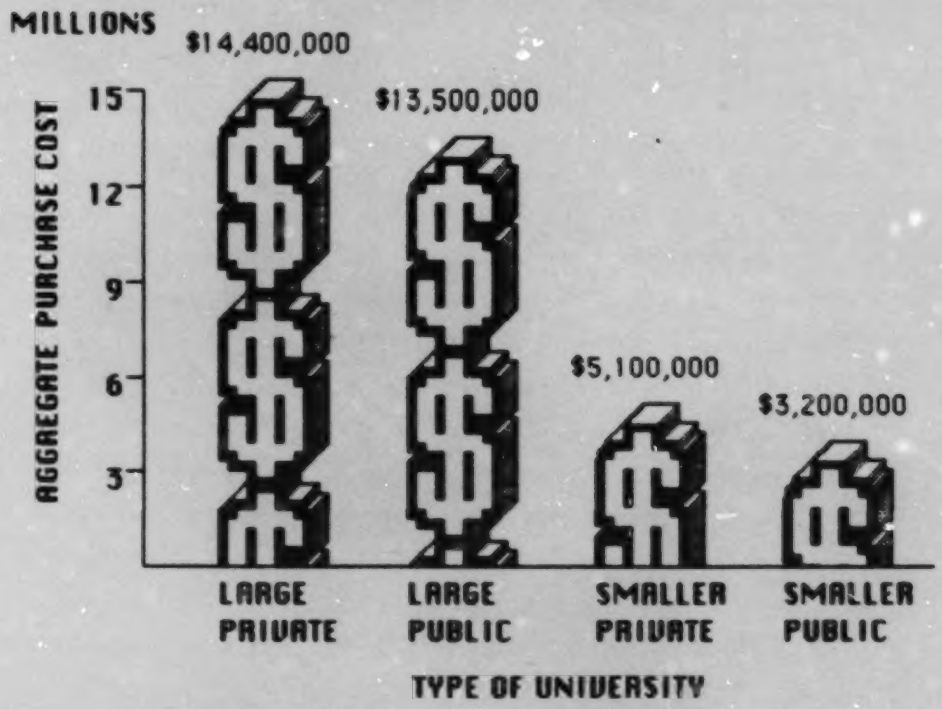
Unitized Dollar Amount of Research Equipment

Several indices of equipment-intensiveness were examined, e.g., aggregate dollar value of research equipment per graduate student or per faculty scientist/engineer. In terms of each of these indicators, the physical sciences were the most equipment-intensive, computer science was least equipment-intensive, and engineering fell in between (see Appendix Table B-5). The differences in favor of the physical sciences would have been even greater if the study had included instrument systems costing over $1 million. Even after excluding 16 large University-Administered Federally-Funded R&D Centers (Oak Ridge, Lincoln Lab, Argonne, etc.), extrapolation of findings from the survey sample indicated that there were an estimated 40 to 50 additional multi-million dollar "super-systems" in academic settings. These super-systems contained roughly $250 million in additional research equipment, almost all of which was used primarily for research in high energy physics or in astronomy.

The 38 largest R&D universities in the nation were estimated to house slightly more than one-half of the 1982 national stock of academic research instrument systems and represented slightly more than one-half of the aggregate cost of these systems. Since these institutions also accounted for slightly more than one-half of all academic R&D expenditures during 1982, it would appear that the largest R&D performers were not very different from smaller universities in the proportion of total available R&D funds invested in major instrument systems. The same was true for public and private universities: within R&D size groupings, public and private institutions had approximately the same mean numbers of research systems (see Figure 7).

In examining the cost of systems in the national stock, it was apparent that although systems costing $75,000 to $1,000,000 were uncommon (accounting for only 13 percent of all systems in the $10,000 - $1,000,000 range), they accounted for 46 percent of the aggregate costs (see Figure 8). Smaller public universities had a somewhat lower proportion of high-cost instrument systems than other types of universities.

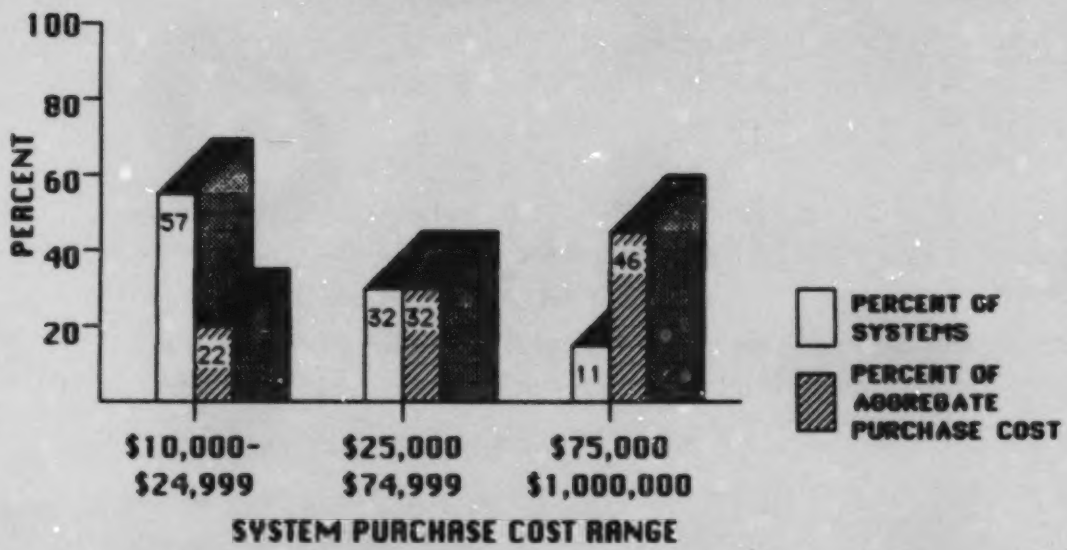
Figure 7. Mean amount (cost) of academic research instrumentation per university



NOTE: Large university refers to separately budgeted R&D expenditures of $33 million or more; smaller university refers to FY 1980 R&D expenditures of $28-32.9 million.

Reference: Appendix Table B-6

Figure 8. Instrument cost distributions: percent of systems vs. percent of aggregate purchase cost of systems



Reference: Appendix Tables B-7 and B-8

RESEARCH STATUS, AGE, AND CONDITION

HIGHLIGHTS

- One in every four instrument systems in the 1982 national stock was completely inoperable or inactive throughout 1982 and was, in effect, obsolete.
- About 50% of the research systems in existence as of December 1982 were acquired within the previous 5 years; however, another 30% were more than 10 years old.
- Computer science had the newest equipment (78% acquired in the previous 1 to 5 years), while materials science had the oldest equipment: 52% of the systems were over 10 years old.
- Only 16% of the research instruments in the 1982 national stock were rated state-of-the-art in early 1983. Of all instrument systems that were not state-of-the-art, half (49%) were the most advanced to which the researchers who used them had access.
- For all of the major research fields surveyed, the median age of state-of-the-art systems was three years or less.
- 51% of the instrument systems actually in use in 1982 were rated as being in excellent working condition.
- As might be expected, condition tended to deteriorate with age; most (70%) systems that were more than 5 years old and still in use were not in excellent condition.

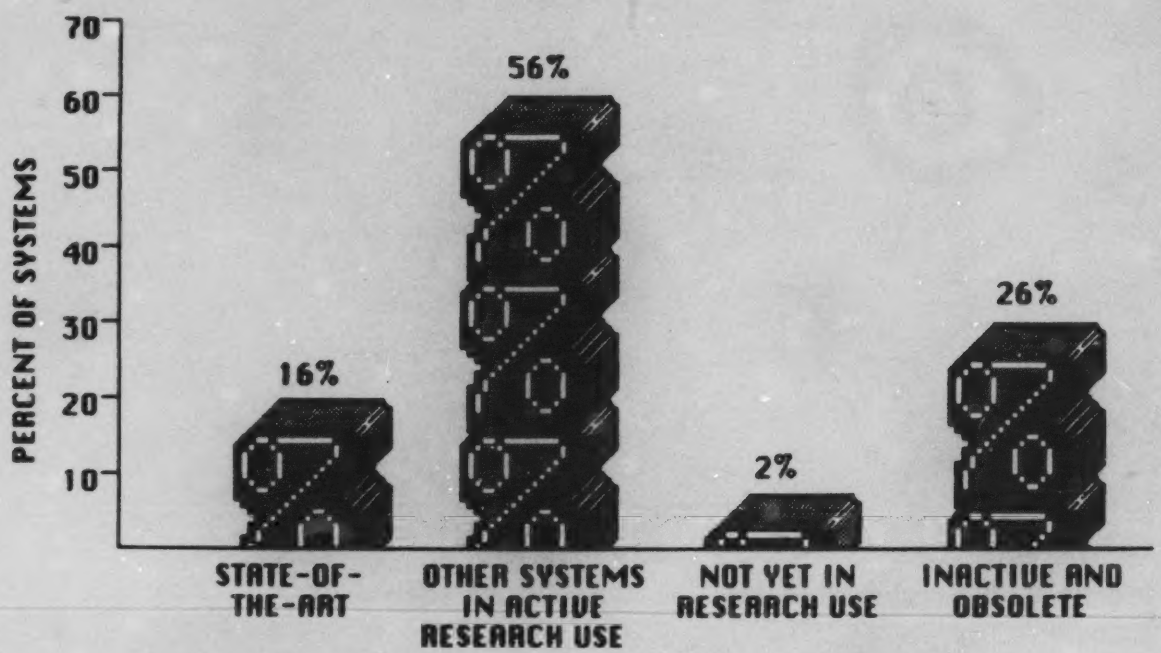
DISCUSSION

This section reviews baseline survey findings regarding three basic parameters: the research status and the age of instrumentation in the 1982 national stock, and the (user-reported) condition of equipment in active research use in 1982. In the research fields surveyed, 28 percent of the national stock of existing academic research instruments systems were not used for scientific research in 1982. Although 2 percent of the systems were still under construction, 26 percent, or one in every four instruments in the national stock, were mechanically inoperable or completely

inactive for other reasons throughout the entire year. It would appear that these systems were totally obsolete, mechanically and/or technologically, although they were still listed on university property inventories and they were, in fact, still physically present.

As indicated in Figure 9, which presents the research status of the instrument systems, 16 percent of the academic research systems were considered to be state-of-the-art by their principal users. The remaining 56 percent of the systems in the 1982 national stock were used for research purposes but were not considered state-of-the-art. There was little variation by research field or type of institution concerning the issue of instrumentation status (see Appendix Table B-9).

Figure 9. Research status of academic research instrumentation in 1982 national stock

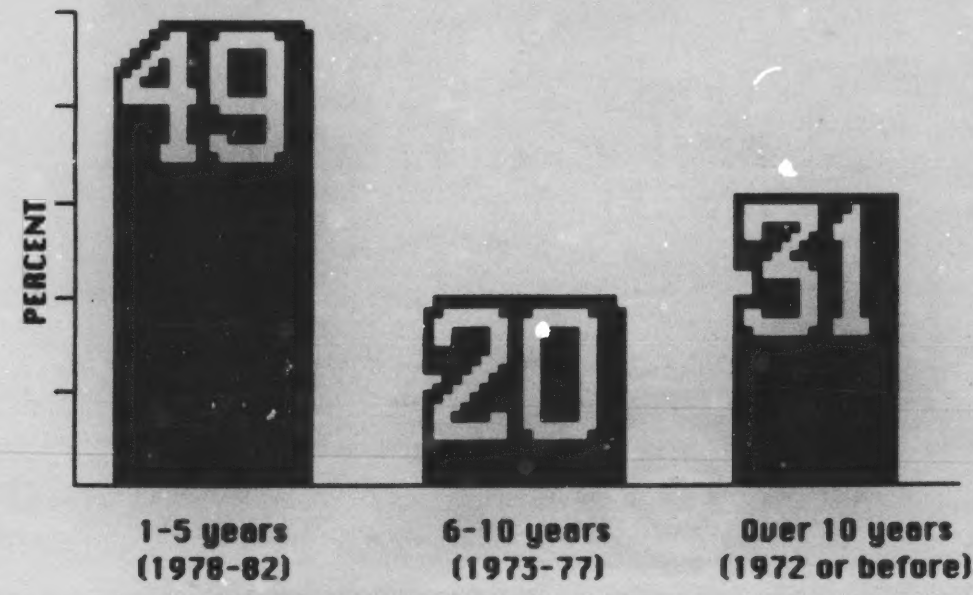


Reference: Appendix Table B-9

Age of Research Equipment

Reviewing the data concerning age of research equipment presents some interesting findings. For the fields surveyed, almost half (49%) of the research instrument systems in existence as of December 1982 had been acquired within the last five years (see Figure 10). There was still a substantial percentage of systems which were over 10 years old (31%). In approaching these data by fields, computer science was the field with the newest equipment by far as 78 percent of the systems had been purchased within the previous five years. (See Appendix Table B-16.) Materials science had the oldest equipment, reporting 52 percent of their instrument systems in the over 10 years old range. Engineering and the physical sciences were more closely in line for the 1 to 5 years range (53% and 45%, respectively). Although the difference between the two fields remained fairly slight, the physical sciences did report a higher percentage in the over 10 years old range when compared to engineering (34% and 29%).

Figure 10. Age of academic research instrument systems



Reference: Appendix Table B-15

Instrument Systems Classified as State-of-the-Art

As can be seen in Appendix Table B-17, only 16 percent of the instrument systems in the fields surveyed were classified as state-of-the-art. When these systems were broken down by purchase cost, 24 percent of systems in the $74,000 to $1,000,000 range were state-of-the-art. The $10,000 to $24,999 range had the fewest state-of-the-art systems (13%). In general, state-of-the-art percentages did not vary greatly by field or by type of institution. Although related to instrument age and cost, even the newest and the most costly of existing equipment was rarely considered state-of-the-art. In fact, as illustrated in Figure 11, only 38 percent of the research instruments purchased in 1982 were rated as state-of-the-art.

Figure 11. Percent of systems classified as state-of-the-art

Reference: Appendix Table B-18

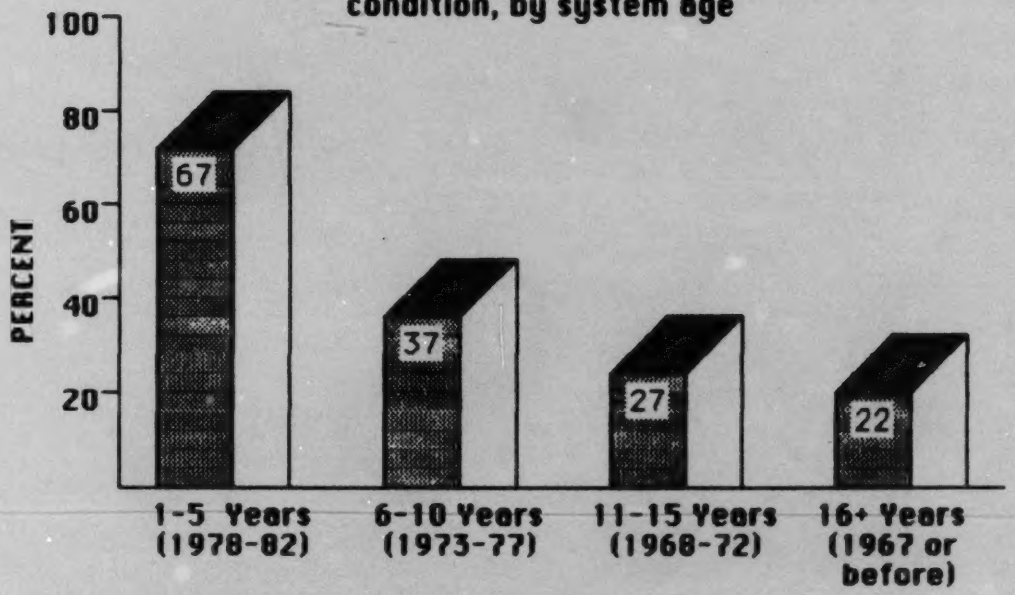
When looking at the age of state-of-the-art research instrument systems, 80 percent of these systems were purchased within the five year period 1978 to 1982. (See Appendix Table B-19.) The median age of these systems was three years or less in all of the major research fields surveyed. Of special note is the field of computer science where, perhaps, the rapid pace of technological evolution is most apparent: the median age of state-of-the-art equipment in computer science was one year. (Appendix Table B-20.)

By comparison, the median age for all instrument systems in the 1982 national stock was six years. While computer science had the smallest median, (three years), the median was highest for materials science (11 years old). There were no appreciable differences by type of university.

Condition of Research Systems

Of all the systems actually in use in 1982, 51 percent were rated as being in excellent condition. As might be expected, condition tended to deteriorate with age (see Figure 12). When examining the instrument systems in terms of age and working condition, 67 percent of the systems acquired within the last 5 years were judged to be in excellent working condition. However, most systems (about 70%) that were more than 5 years old and were still in research use were not in excellent condition. (Appendix Table B-21.)

Figure 12. Percent of systems in excellent working condition, by system age



Reference: Appendix Table B-21

As one might expect, most state-of-the-art systems (84%) were in excellent working condition (Appendix Table B-22). However, for the majority of in-use systems, those that were not state-of-the-art, only 42% were considered to be in excellent condition. There was little difference by field or type of university, although in computer science an above average 50% of the systems which were not state-of-the-art were rated as being in excellent working condition.

By itself, the existence of substantial amounts of non-state-of-the-art research equipment is not a problem. Even the best-equipped research facilities would be expected to have such equipment — for use in routine analyses, as backups for more advanced instruments, etc. Non-state-of-the-art equipment is a problem only in situations where the users of such equipment do not have access to more advanced equipment when needed. Appendix Table B-23 shows that this problem situation was not uncommon in 1982: half (49%) of all non-state-of-the-art instrument systems in research use in the fields surveyed were the most advanced instruments of their kind to which their research users had access. As would be expected, the percentage was lower at large R&D institutions (41% to 43%) than at smaller R&D centers (54% to 58%).

FUNDING SOURCES

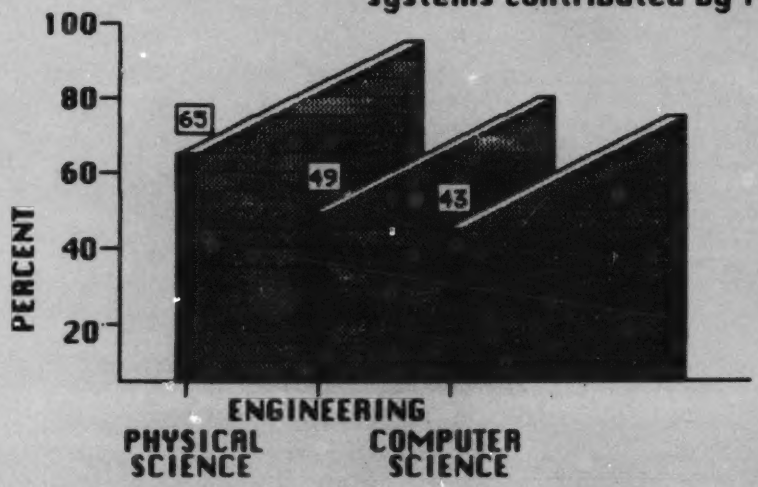
HIGHLIGHTS

- 58% of the funds for acquisition of in-use academic research equipment in the fields surveyed came from Federal sources.
- About 5% of the instrument systems were not "funded" in the usual sense: some were acquired at no cost from government surplus, some were donated, and some were transferred by incoming faculty.
- In the fields surveyed, NSF was the principal Federal funding source, accounting for 27% of the aggregate acquisition cost of all in-use equipment.
- Joint Federal - Non-Federal funding packages were not uncommon for research equipment; 1 out of every 4 in-use instrument systems were acquired with partial Federal funding.

DISCUSSION

Overall 58 percent of the funds for acquisition of in-use academic research equipment in the fields surveyed came from Federal sources. By field, Federal funding support was greatest in the physical sciences (65%). See Figure 13. As shown

Figure 13. Percent of aggregate acquisition cost of in-use systems contributed by Federal sources



Reference: Appendix Table B-26

in Appendix Table B-26, Federal funding support was heaviest in physics/astronomy, accounting for 80 percent of the aggregate acquisition cost of all in-use equipment in this subfield. Materials science was next with 73 percent, followed by electrical engineering with 70 percent. Federal funding was least prominent in civil engineering (19%). It was also comparatively low for computer science (43%).

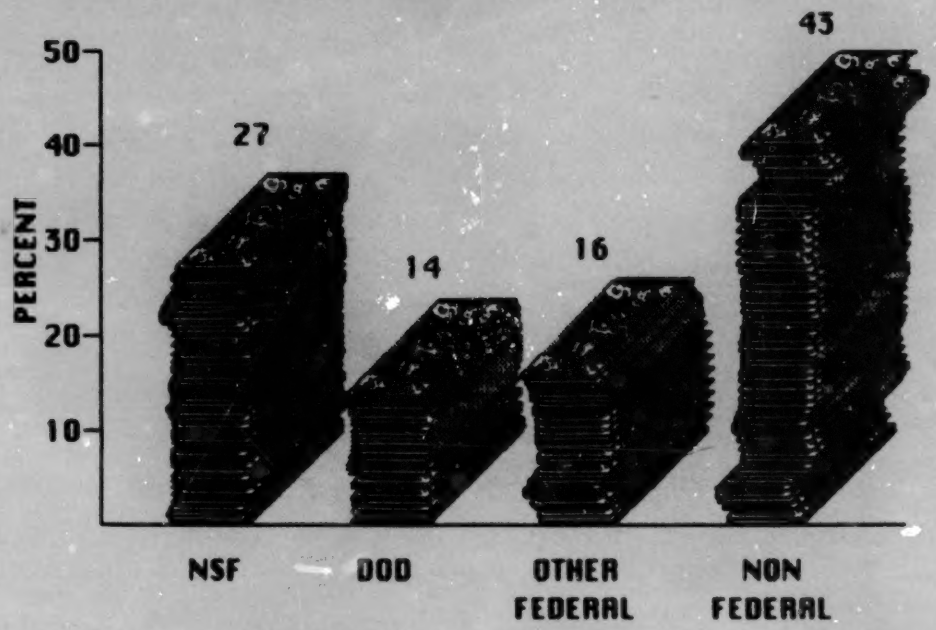
Large private universities enjoyed the greatest success in attracting Federal support for purchase of research equipment. Seventy-three (73%) percent of the aggregate acquisition cost of all in-use research equipment were contributed by Federal funding sources. As shown in Appendix Table B-2, smaller public universities were the least successful (41% of aggregate cost). Other types of universities (large public and small private) were intermediate (59% and 63%, respectively).

Not all the instrument systems used for research in 1982 were "funded" in the usual sense. Some were acquired at no cost from government surplus (2%). Others were donated by industry, foundations, or private individuals (3%). Still others were loaned by the manufacturers, were transferred to the current host institution by incoming faculty, or were acquired in other ways without cost to the university (2%). In addition, some other research equipment was acquired in ways that involved minimal cost: it was purchased used (4%), or it was constructed at the university (4%). However, the great majority of in-use academic research instrument systems in the fields surveyed (84%) was purchased new from the manufacturer and did require funding support.

Federal Funding Sources

In the fields surveyed, NSF was the principal Federal funding source, accounting for 27 percent of the aggregate acquisition cost of all in-use research equipment (see Figure 14). NSF was particularly prominent in the field of materials science, accounting for 42% of the aggregate cost of all equipment in use. In the fields of engineering and computer science, both NSF and the Department of Defense were notable -- and roughly equal -- funding sources. Combined, the two sources of funding accounted for about 40 percent of the aggregate equipment acquisition cost.

Figure 14. Principal sources of funding for acquisition of in-use research equipment



Reference: Appendix Table B-25

In addition, the Department of Energy was also a significant source of funding in some fields. For example, within the physical sciences, DOE provided 17 percent of the funding for equipment in physics/astronomy and, within engineering, provided 11 percent of the funding for materials engineering. In another major field, materials science, 10 percent of its instrumentation funding was from DOE (See Appendix Table B-25).

Funding by Type of University

In examining funding sources by type of university, large public universities relied on State government sources and university budgets for 36 percent of their aggregate instrumentation funding. (It is important to remember that university budgets for public universities are ultimately state government sources as well.) These same sources accounted for 49 percent of instrumentation funding at smaller public universities. (Refer to Appendix Table B-25.) By comparison, internal university sources accounted for only 17 and 25 percent, respectively, at large private and small private universities.

Joint Funding Packages

Joint funding packages were not uncommon for research equipment. One in every four instrument systems in use was acquired with partial Federal funding in combination with other funding sources. (Refer to Appendix Table B-27.) Despite the number of instrument systems acquired by joint funding, most equipment was purchased either with 100 percent Federal funding (43%) or with 100 percent non-Federal funding (32%). Computer science had the largest percentage of equipment purchased without Federal funding of any kind (44%). Materials science reported the largest percentage of instrument systems purchased totally with Federal funding (57%) and both fields were equal in the percentage (32%) of equipment obtained with at least partial Federal funding. In examining the percent of systems with 50 percent or more Federal funding by year of purchase, it would appear that there was a slight decrease in the number of systems funded this way during the period between 1978 and 1982. (See Appendix Table B-28.)

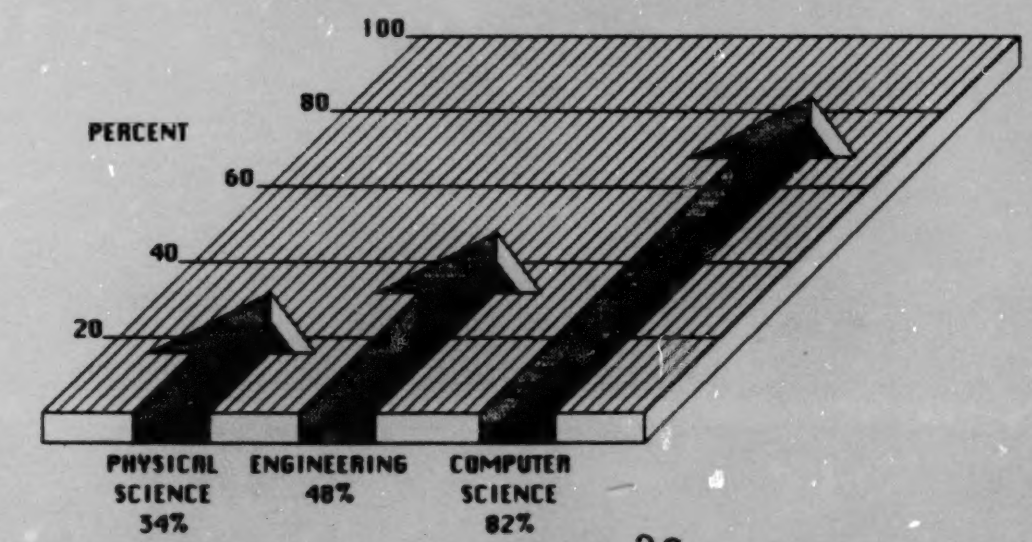
A little more than half (55%) of the instrument systems in the $10,000 to $1,000,000 range in the fields surveyed were located in within-department laboratories of individual principal investigators. The remainder of the systems (see Appendix Table B-30) were located in a variety of inherently shared-accessed facilities: department-managed common laboratories or instrumentation facilities (32%); national, regional, or inter-university research instrumentation laboratories (2%); and other nondepartmental research facilities (8%).

Locational Distribution of Equipment

When comparing the locational distribution of state-of-the-art equipment versus other in-use systems (not considered state-of-the-art), there was no substantial difference. As can be seen from Appendix Tables B-31 through B-33, instrument location patterns were also unrelated to institution R&D size, control, or year of purchase.

The physical sciences had comparatively little instrumentation in shared-access facilities (29%). At the other extreme, most computer science and materials science equipment (both at 82%) were located in shared-access facilities (see Figure 15 and Appendix Table B-31).

Figure 15. Percent of in-use research systems located in shared-access facilities in 1982



Reference Appendix Table B-31

LOCATION AND USAGE

HIGHLIGHTS

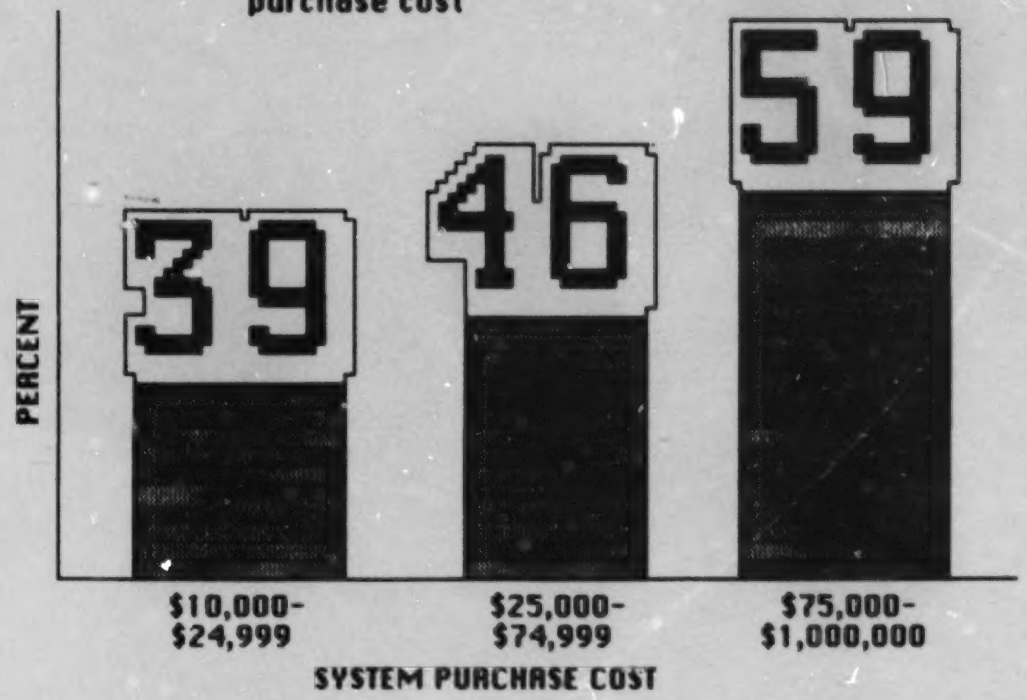
- Almost half (45%) of instrument systems in the fields surveyed were located in shared-access facilities; the rest were located in within-department laboratories of individual principal investigators.
- 35% of all in-use research systems were not amenable to general purpose usage, but rather were "dedicated" for use in a particular experiment or series of experiments.
- Instrument location patterns were unrelated to whether or not the equipment was state-of-the-art, the institution's R&D size or control, or the year of purchase.
- Most computer science and materials science equipment was located in shared-access facilities.
- Location of equipment was directly related to cost, with the most expensive equipment being most likely to be located in shared-access facilities.
- For equipment in use, the mean number of users per system in 1982 was 18. The mean number of users of dedicated systems was 8, while the mean number of users for general purpose equipment in 1982 was 23.
- 30% of all in-use systems were used, in part, by researchers from outside the host department or facility.
- Widespread usage beyond the host department or facility was especially common for equipment at the upper end of the cost range and for equipment in the fields of computer science and materials science.

DISCUSSION

This section presents a variety of indicator statistics pertaining to the extent of use of academic research equipment and factors that may affect instrument usage, such as the type of research facility in which the instrument is located and whether or not the instrument is "dedicated" for use in a particular experiment.

Location of equipment was directly related to cost. Thus, while only 39 percent of the $10,000 to $24,999 systems were in shared-access facilities, 59 percent of the $75,000 to $1,000,000 instrument systems were located in such facilities (see Figure 16).

Figure 16. Percent of in-use research systems located in shared-access facilities in 1982, by system purchase cost



Reference: Appendix Table B-32

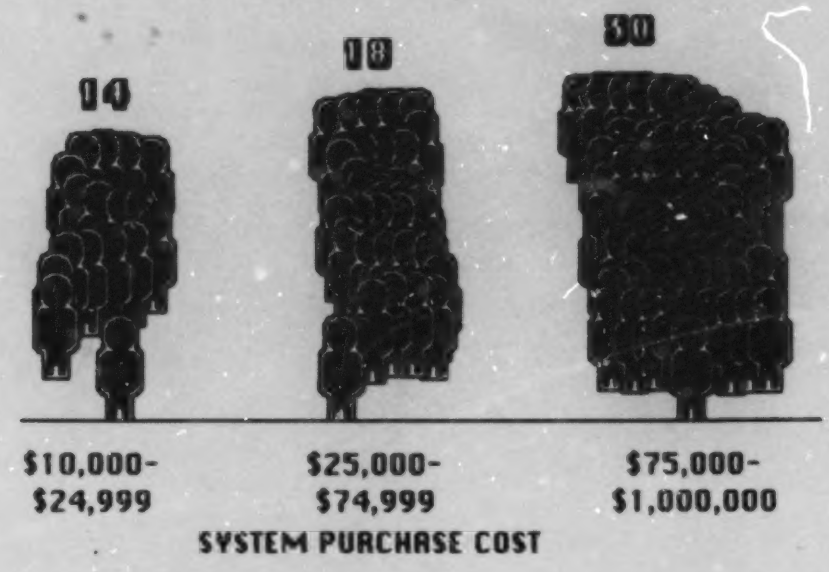
In addition to location of equipment, the survey examined the usage of instrument systems. There were some instrument systems which were not amenable to general-purpose, shared usage. These systems were designated as having been "dedicated" for use in a particular experiment or series of experiments. As shown in Appendix Table B-34, 35 percent of all the in-use systems in the fields surveyed were "dedicated" in this manner. Dedicated equipment was more common in the physical

sciences (37%) than in other fields. This was particularly true because of the large percentage of dedicated equipment in physics and astronomy (46%). Dedicated equipment was least often encountered in computer science (17%) and materials science (20%).

Number of Users Per System

During FY 1982, the mean number of users per system for equipment in use, was 18. As might be expected, dedicated systems had fewer users on the average. The mean number of users for these systems was 8. The mean number of users in 1982 of systems that were available for general purpose use was 23. (See Appendix Table B-35.) As shown in Figure 17, the mean number of instrument system users was directly related to system cost.

Figure 17. Mean number of system users in 1982



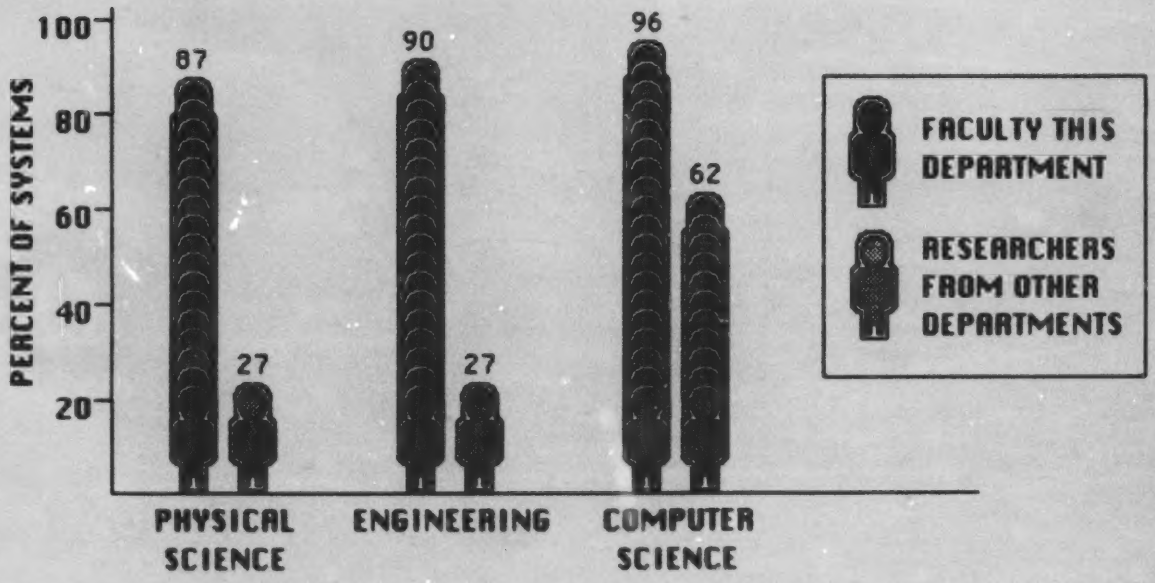
Reference: Appendix Table B-35

Computer science was the field with the largest mean number of users (64), followed by materials science (36). There was little difference between the physical sciences and engineering (with means of 15 and 14 years, respectively). Within engineering, electrical engineering had the highest mean number of users (20). As indicated in Appendix Table B-36, the lowest mean number of users per system was in the field of chemical engineering with an overall average of 6 users. For all other fields surveyed the mean number of users was in the 11 to 18 range in 1982. In looking at general purpose equipment, as opposed to dedicated equipment, the mean number of users was considerably greater at the large private universities (50 users per system) than at other types of universities (means ranged from 15 to 20 users per system).

Types of Users of Academic Instruments

Nearly all in-use equipment was reportedly used by faculty and/or by graduate students and post-doctorates in the departments and facilities where the systems were located. In addition, a great deal of the equipment was used by researchers from other departments of the university (30% of all in-use systems), by researchers from other universities (13%), and/or by nonacademic researchers (9%). As is evident from Appendix Table B-42, widespread usage beyond the host department or facility was especially common for equipment at the upper end of the cost range, particularly for those systems in the $75,000 to $1,000,000 cost range. In addition, there was especially widespread use of equipment by researchers other than those in the host facility, in the field of computer science (see Figure 18).

Figure 18. Types of users of academic research instruments in 1982



Reference: Appendix Table B-43

MAINTENANCE AND REPAIR

HIGHLIGHTS

- For every $1.00 spent purchasing research equipment in FY 1982, an additional 25 cents was spent providing instrument maintenance and repair.
- An average (mean) of $50,000 was spent for the maintenance and repair of research equipment by the departments and facilities surveyed.
- Only 6% of the departments surveyed assessed their maintenance and repair facilities as "excellent."
- With the exception of computer science equipment, 46% of all in-use instrument systems (in the $10,000 to $1,000,000 range) received all needed maintenance and repair work from on-campus personnel.
- Service contracts were used predominately within the first 5 years of instruments' life spans; only 6% of in-use systems over 5 years old were maintained through service contracts.
- The mean cost of service contracts was $5,700 compared to the mean expenditures of $2,200 for instruments where field service was used.

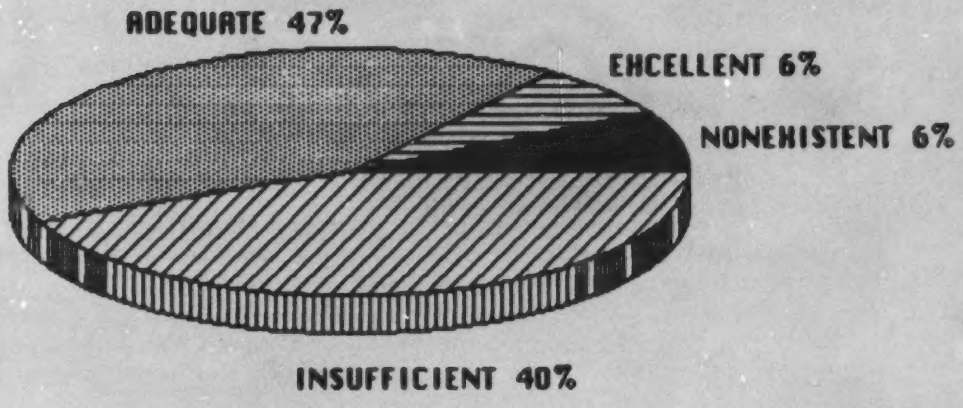
DISCUSSION

As part of a national survey examining costs of academic research equipment, it is important not to overlook costs of instrument maintenance and repair. In addition to constituting a major component of total instrumentation-related costs, institutions' maintenance/repair practices and provisions may significantly affect instrumentation condition and longevity.

Across the 1,200 physical and computer science and engineering departments represented in this survey, an average (mean) of $50,000 per department was spent in FY 1982 for maintenance and repair of research equipment (see Appendix Table B-45). In effect, for every dollar spent to acquire new research equipment, an additional 25 cents was spent to maintain and repair existing equipment. Average

maintenance/repair (M/R) expenditures in FY 1982 were $88,000 among departments that described their instrumentation M/R facilities as "excellent;" however, only 6 percent of the departments surveyed were in this category. A much larger 40 percent of departments characterized their maintenance/repair capabilities as insufficient, and an additional 6 percent reported not having any M/R facilities at all (Figure 19).

Figure 19. Distribution of department/facility assessments of their instrumentation support services



Reference: Appendix Table B-44

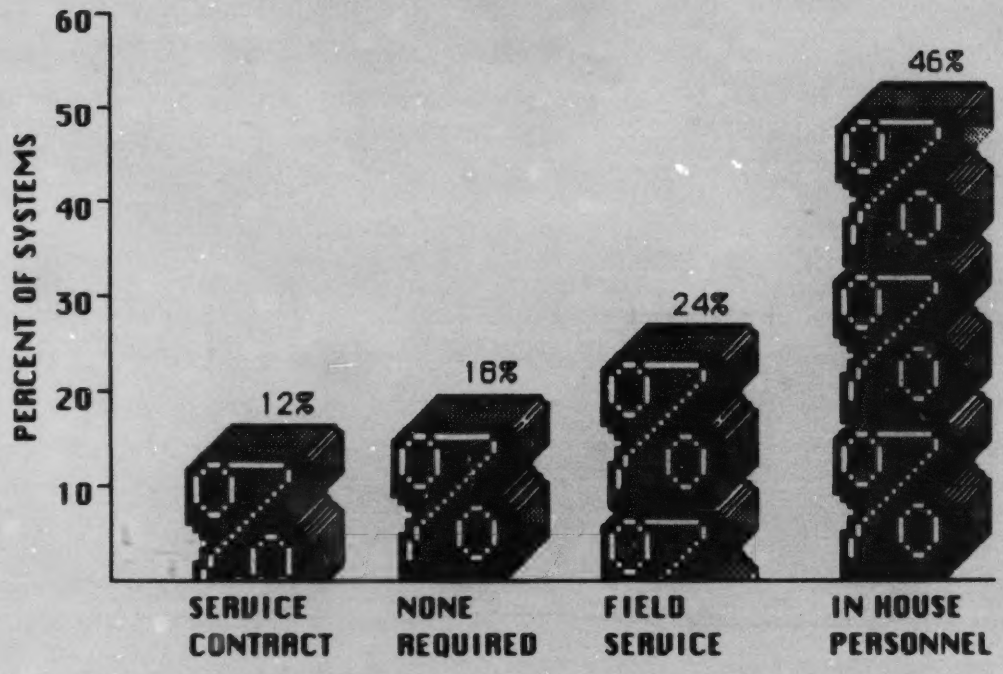
Repair and Maintenance Expenditures

In examining the composition of repair and maintenance expenditures reported by departments and facilities, the bulk of the expenditures in FY 1982 was for salaries of university-employed maintenance/repair personnel (52%) or for service contracts and field service for individual instruments (29%). (See Appendix Table B-45.) The remainder was spent for M/R supplies and equipment (e.g., machine shop, electronics shop).

Overall, 46 percent of in-use instrument systems in the $10,000 to $1,000,000 range received all needed maintenance and repair work on-campus. This "in-house" M/R work was almost evenly split between university-employed M/R staff

and research personnel, i.e., faculty, graduate students, post-doctorates. For the remaining equipment in this cost range, 12 percent were under service contract while 18 percent were not, but also did not require any maintenance or repair work during FY 1982. (See Figure 20.) The rest used field service as needed. Most individual fields fit this general pattern — except for computer science. In that field, half of all equipment was covered by service contracts, and most of the rest received professional field service when needed. (See Appendix Table B-46.)

Figure 20. Principal means of servicing in-use research systems in 1982



Reference: Appendix Table B-46

Overall for the fields studied, departments/facilities at large private universities spent twice as much for equipment maintenance and repair as did departments/facilities at large public universities ($124,000 and $64,000, respectively). Less was spent ($43,000 and $32,000, respectively) for instrument maintenance and repair at smaller institutions, both private and public. (See Appendix Table B-45.) On

a department-level basis, physics/astronomy departments spent the most for research equipment maintenance/repair in FY 1982 (mean = $91,400); engineering departments spent the least (mean = $29,800).

Means of Servicing Related to System Age and Cost

The principal means of servicing in-use academic research instrument systems was strongly related to system age. Service contracts, for example, were most likely to be used within the first five years of the instrument's life span. Seventeen percent of all in-use systems purchased within the last five years had service contracts in place, but this percentage dropped to 6 percent for systems over five years of age. (See Appendix Table B-47.) Conversely, older equipment over 10 years of age was much more often serviced by on-campus personnel (university-employed M/R staff or the instrument's research users) than was newer equipment under 6 years of age: 62 percent vs. 36 percent, respectively.

For instruments where the purchase cost was in the $75,000 to $1,000,000 range, FY 1982 expenditures for maintenance and repair averaged (mean) $7,200. In the $50,000 to $74,000 range, the mean was $1,600; for the $10,000 to $24,999 range, the mean was $500 in expenditures for maintenance and repair. (See Appendix Table B-48.)

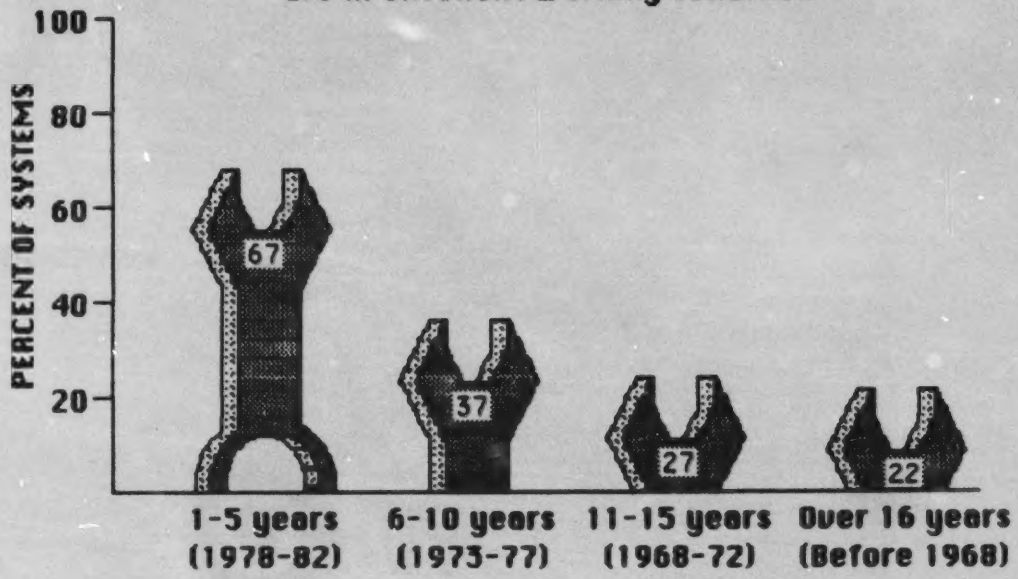
The mean annual cost of service contracts was $5,700, far greater than the overall average M/R expenditure of $1,700 per system. Average maintenance/repair costs per system declined slightly as system age increased.

It is interesting, however, that in every age group, instruments serviced primarily by ad hoc field service or by the instrument's research users were less likely to be in excellent working condition than instruments in general (Appendix Table B-47.)

As would be expected, the percentage of systems in active research use that were reported in excellent working condition declined rapidly with age. (See

Figure 21.) This was true no matter what kind of servicing they had received in 1982. Among "middle-aged" instruments in the 6 to 10 year range, those that had been serviced primarily by service contracts were far more likely to be in excellent working condition than those serviced by other means: 52 percent vs. 25-33 percent. This suggests that the high cost of maintaining service contracts in force (when offered by the manufacturer) may have long range benefits in terms of improved equipment reliability and longevity.

Figure 21. Percent of in-use research systems that are in excellent working condition



Reference: Appendix Table B-47

APPENDICES

APPENDIX A

Technical Notes

TECHNICAL NOTES

SAMPLE DESIGN

Institutions. Survey data were collected from a stratified probability sample of 43 institutions selected from the 157 largest academic research and development (R&D) performers in the nation, excluding University-administered, Federally-funded R&D Centers (FFRDC's). Specifically, the "universe" to which the Phase I survey findings apply consists of the 157 nonmedical, nonmilitary U.S. colleges and universities that had $3 million or more in separately-budgeted science and engineering (S/E) R&D expenditures in any of the fiscal years FY 1977 to FY 1980.[1]

These 157 institutions collectively accounted for 95 percent of all nonmedical, non-FFRDC R&D expenditures reported to NSF for FY 1980 by all U.S. colleges and universities. Thus, although the survey represented only a small fraction of the nation's approximately 3,000 postsecondary institutions, it encompassed most institutions with significant capabilities for the kinds of advanced research that require instrumentation in the $10,000+ range.

In selecting the study sample of 43 institutions, the probability of selection of each institution in the survey universe was approximately proportionate to its R&D size, as indicated by its FY 1980 nonmedical, S/E, R&D expenditures. Within R&D size classes, the proportion of private (or public) institutions in the sample was approximately the same as in the nation as a whole. The design is summarized in Table A-1.

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[1] Academic Science R&D Funds, Fiscal Year 1980: Detailed Statistical Tables. Surveys of Science Resources Series, National Science Foundation, (GPO Publication No. NSF82-300), 1982.

Table A-1. Institution sample design

FY 1980 S/E R&D expenditures	No. institutions in nation			No. institutions in sample		
	Total	Private	Public	Total	Private	Public
Total, all institutions over $3 million	157	53	104	43	15	28
Large institutions, total	38	11	27	23	7	16
Over $90 million	3	2	1	3	2	1
$52.5-$89.9 million	15	3	12	10	2	8
$33-$52.4 million	20	6	14	10	3	7
Smaller institutions, total	119	42	77	20	8	12
$19-$32.9 million	30	11	19	10	4	6
$3-$18.9 million	89	31	58	10	4	6

Departments and Facilities. At each sampled university, all institution-operated departments and nondepartmental research/instrumentation facilities in the physical sciences, engineering, or computer science that contained any research instrument systems in the $10,000 to $1,000,000 cost range were identified and asked to participate in the survey. Excepted from this sample were: (a) general purpose university computer centers, and (b) other nondepartmental instrumentation facilities that, in effect, consisted of a single system costing over $1,000,000 (research reactors or cyclotrons, observatories, etc.). A total of 438 "in-scope" departments and facilities was identified, each of which was asked to complete a Department/Facility Questionnaire inquiring about the department's (or facility's) instrumentation-related needs, priorities, expenditures and sources of funding support (see Appendix E).

The 43 sampled institutions contained 66 other instrumentation facilities that were excluded because they were beyond the scope of this survey. Of these, 44 were general purpose university computer centers. Most of the rest (19 of 22) were multimillion dollar instrument systems in high energy physics or astronomy.

Instruments. The survey sought to represent all instrument systems at "in-scope" departments that: (a) were used or intended primarily for research, and (b) originally cost $10,000 to $1,000,000 including the cost of any separately-purchased, dedicated accessories or components.

Briefly, the sequence of steps at each department and facility was as follows. First, a preliminary listing of all $10,000+ items of research equipment was obtained, usually from the university's computerized central property inventory system. Often, the preliminary lists were overly inclusive, containing in addition to items of research equipment, miscellaneous property such as furniture, physical plant equipment (e.g., trucks, heating and air conditioning units), secretarial equipment (e.g., word processors), and the like.

Second, after screening out clearly inappropriate entries, the contractor selected a random probability sample of $10,000+ items in each department and facility. The instrument sample design took account of the amount and cost of equipment in the listing. If the number of items costing $50,000+ was 12 or less, all were included; otherwise, all items costing $100,000+ were included and a simple random sample of 1 in 3 items in the $50,000 to $99,999 range was selected. For items in the $10,000 to $49,999 range, sampling rates ranged from 100 percent for departments/facilities with 1 to 9 such items down to 12.5 percent (1/8) for departments/facilities with over 100 items in this cost range. The intent of this design was to ensure adequate sample size for analysis without overburdening large departments and facilities.

Across the 438 eligible departments and facilities in the 43 sampled institutions, a total of 12,691 equipment items were identified in preliminary listings; of these, 4,648 were selected to be in the survey sample. Overall, the equipment

sample included 1,512 of 1,771 items costing $50,000+ (85%) and 3,135 of 10,920 items in the $10,000 to $49,999 range (29%).

The final step was that, for each sampled instrument, department/facility administrators were asked to arrange for a brief Instrument Data Sheet to be filled in by the responsible principal investigator or other person knowledgeable about the instrument's status, cost, and condition (see Appendix F). Department/facility administrators were also asked to review the university-provided preliminary equipment listing for their department/facility and add any additional items of $10,000+ research equipment that might have been omitted.

Estimation Procedures. All results reported in this report are in the form of national estimates statistically weighted to represent all research departments and nondepartmental research facilities in the physical and computer sciences and engineering at the 157 largest R&D universities in the nation.

The estimation weights applied to department/facility questionnaire data were easily computed. Since all applicable departments and facilities in each sampled university were asked to participate in the survey and since nearly all of them actually did provide usable questionnaire responses, the estimation weight for each responding department was simply the inverse of the selection probability of the university in which the department or facility was located, multiplied by a small nonresponse adjustment factor.

Estimation weights for the survey of $10,000 to $1,000,000 instruments were somewhat more complex. The weight for a completed instrument questionnaire was the product of:

- The university sampling weight — the inverse of the university's probability of selection;
- The instrument sampling weight — the inverse of the probability of selection of the particular instrument from the department or facility equipment list;

- An adjustment to the initial instrument sampling weight in situations where the instrument was part of a larger system with two or more separately-listed components in the $10,000 to $1,000,000 range (in which case, the system selection probability was larger than the selection probability for any one component); and

- A nonresponse adjustment, where needed.

Survey Administration. At each institution, all data collection arrangements were handled by a survey coordinator appointed by the Office of the President of the university. Typically, coordinators were themselves senior administrators, such as Dean of the Graduate School or Vice President for Research. These individuals were responsible for identifying all pertinent departments and facilities. In addition, they were responsible for obtaining needed preliminary lists of equipment, and after equipment samples had been selected by the survey contractor, arranging for the distribution, completion, and return of survey questionnaires.

Survey Response. In a complex, multistage survey such as this, there are several levels or types of response to consider. At the institution level, the response rate was 100 percent. The university administration at all 43 sampled institutions promptly agreed to participate in the survey and appointed a coordinator. The coordinator arranged for the preparation and delivery of preliminary equipment listings for all applicable departments and facilities. Subsequently, the coordinator arranged for the delivery and return of survey materials to and from these departments/facilities.

Completed Department/Facility Questionnaires were received from the heads of 403 of the 438 eligible departments and facilities (92%). Even more impressive, faculty researchers returned completed Instrument Data Sheets for 4,443 of the 4,648 instruments in the equipment sample (96%). Of the remaining 205 equipment items for which usable responses were not received, only seven were outright refusals. The rest of the nonresponse was due almost entirely to the absence of knowledgeable respondents during the survey period. As would be expected with overall response rates this high, no significant differences were found by type of

institution, by field of research, or by instrument cost range in department/facility or in equipment response rates.[2]

Definitions. The following definitions and guidelines are provided to aid in the effective use of the data in this report.

Field of Science/Engineering. This report is limited to the physical and computer sciences, engineering, and interdisciplinary combinations of these research fields. Field classifications for "active" research instruments are based on user descriptions of the instruments' principal field of research use in 1982. Field classifications for departments and facilities and for instrument systems that were not used for research in 1982 indicate the principal field of research in the department or facility. The particular field categories listed in a given table (e.g., the number of engineering subfields listed, if any) are as differentiated and disaggregated as possible, in view of the need to retain cell sizes large enough to produce statistically reliable data.

In its most detailed form, the field typology is as follows:

Physical Sciences

Chemistry (physical, inorganic, organic, polymer; not biochemistry)
Physics and astronomy

[2]The above figures indicate cumulative response to date. The statistical analyses in this report are based on responses received by September 23, 1983: 378 department questionnaires (86%) and 4,177 instrument data sheets (90%). Of the 4,177 responses in the equipment survey, 2,582 were instruments (or principal components of instrument systems) in active research use in 1982, 846 were research instruments that were physically present at the end of 1982 but had not been used for research during the year, and the remaining 749 were classified as outside the scope of the study for one reason or another (e.g., dedicated accessories of systems represented by other data forms, instruments used principally for teaching or other nonresearch purposes, equipment that no longer exists or was never intended for research use - maintenance vehicles, office equipment, etc.).

Engineering

Electrical (electronic, computer engineering)
Mechanical
Metallurgical/materials (ceramic, mining, mineral, petroleum)
Chemical
Civil (architectural)
Other (e.g., aerospace, agricultural, biomedical, industrial, nuclear, systems)

Computer Sciences

No subdivisions

Interdisciplinary

Materials science (interdisciplinary — not just materials engineering)
Other, n.e.c. (e.g., textile sciences; nuclear science — not just nuclear physics; other multi-field)

Type of University. This variable contains four categories representing all combinations of two dichotomous measures: university control (public vs. private) and R&D size (large vs. smaller). The latter measure is based on institutions' reported FY 1980 total R&D expenditures in all science and engineering fields to be surveyed in Phases I and II. The top 38 institutions, which collectively accounted for about half of all FY 1980 academic R&D expenditures in applicable fields, were classified as "large." The remaining 119 institutions in the survey universe, each of which had R&D expenditures of at least $3 million in at least one of the years FY 1977 to FY 1980, were classified as "smaller."

System. In data collection terms, an instrument system consists of a reference instrument or component selected from a department/facility property list, plus any separately acquired "add-ons" or components that, as of December 1982, were dedicated solely for use with the reference item. The instrument system is the basic unit of reference in the equipment survey, and all reported cost figures reflect costs for the full system — the base unit plus all dedicated accessories. The equipment survey is limited to systems with original purchase cost of $10,000 to $1,000,000.

National Stock. In this report, the term "national stock" of academic research equipment refers to all instrument systems costing $10,000 to $1,000,000 that, as of December 31, 1982, were physically located at an academic institution in the survey universe and were principally used (or intended for use) in original scientific research in one or more of the fields encompassed by the survey. In addition to systems actually used for research in 1982, this includes existing components of nonoperational systems still under construction at the end of 1982 and research systems that were inoperable or inactive throughout 1982.

Purchase Cost. The purchase cost refers to the manufacturer's list price at the time of original purchase (i.e., when new). For multi-component systems, the purchase cost is the aggregate list price of all components and accessories. Except where clearly specified otherwise, all cost/value/investment statistics in this report refer to system purchase cost.

Acquisition Cost. Acquisition cost is the actual cost to acquire the instrument system at the current host university, including transportation and construction/labor costs. For used, discounted or rebated equipment, it is the price actually paid to the seller, plus transportation and installation costs; for donated, loaned, transferred, or surplus equipment, it represents the transportation and installation costs, if any.

Replacement Value. This value is the user estimate of the 1982 purchase cost of the same or functionally equivalent equipment.

1982 Cost-Equivalent. This is the original purchase cost converted to constant 1982 dollars using the Machinery and Equipment index of the Bureau of Labor Statistics' annual Producer Price Index to adjust for inflation. Arithmetically, the value is calculated by multiplying the original purchase cost by the ratio of the 1982 annual PPI index for Machinery and Equipment to the same PPI index for the year in which the instrument system was originally purchased or constructed.

APPENDIX B

Detailed Statistical Tables

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Principal field of research in department/facility, type of university, and size of department/facility	Number of departments/facilities	Percent reporting inability to conduct critical experiments due to lack of needed equipment[2]
Total, selected fields	1,205	90%
Field of research		
Physical sciences, total	371	90
Chemistry	177	93
Physics and astronomy	194	87
Engineering, total	657	91
Electrical	94	96
Mechanical	111	94
Metallurgical/materials	47	95
Chemical	83	94
Civil	105	91
Other, n.e.c.	217	85
Computer science	91	93
Interdisciplinary, n.e.c.[3]	86	81
Type of university[4]		
Large private (N=11)	106	89
Large public (N=27)	322	91
Smaller private (N=42)	259	89
Smaller public (N=77)	518	90
Size of department/facility[5]		
Large ($200,000 or more)	391	89
Medium ($50,000-$199,999)	392	86
Small (under $50,000 or more)	362	95

[1]Statistical estimates encompass all research departments and all nondepartmental research facilities in the physical sciences, engineering and computer science at the 157 largest R&D universities in the U.S., except: (a) departments with no research instrument systems costing $10,000 or more and (b) research installations consisting of interrelated components costing over $1 million (large observatories, reactors, accelerators, etc.). Sample size = 353 departments/facilities.

[2]Estimated percent of departments/facilities identifying "important subject areas (e.g., recombinant DNA, microcircuitry, plasma physics) in which investigators in this department/facility are unable to perform critical experiments in their areas of research interest due to lack of needed equipment."

[3]Includes materials science.

[4]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million; "N" indicates number of institutions in each size class.

[5]Classification is based on reported FY 1982 expenditures for research equipment.

NOTE: Sum of percents may not equal 100 because of rounding.

Table B-2. Department/facility evaluation of adequacy of instrumentation available to research faculty, by field, type of university, and size of department/facility and by type of researcher: National estimates, 1982[1]

Principal field of research in department/facility, type of university, and size of department/facility	Percent of systems, by Adequacy of instrumentation available to tenured faculty and equivalent P.I.s				Percent of systems, by Adequacy of equipment available to untenured faculty and equivalent P.I.s			
	Total	Excellent	Adequate	Insufficient	Total	Excellent	Adequate	Insufficient
Total, selected fields	100%	8%	46%	46%	100%	7%	41%	52%
Field								
Physical sciences, total	100	3	57	40	100	2	50	48
Chemistry	100	7	45	48	100	3	51	46
Physics and astronomy	100	0	68	32	100	0	49	51
Engineering, total	100	10	39	51	100	8	34	58
Electrical	100	20	23	56	100	4	31	65
Mechanical	100	24	23	53	100	24	10	67
Metallurgical/materials	100	0	42	58	100	6	20	74
Chemical	100	3	39	58	100	0	28	72
Civil	100	8	46	46	100	10	42	48
Other, n.e.c.	100	3	51	46	100	3	50	47
Computer science	100	3	55	43	100	3	57	40
Interdisciplinary, n.e.c.[2]	100	28	36	36	100	27	35	38
Type of university[3]								
Large private (N=11)	100	10	62	28	100	4	50	46
Large public (N=27)	100	4	54	42	100	5	43	52
Smaller private (N=42)	100	3	45	53	100	2	32	66
Smaller public (N=77)	100	14	38	48	100	11	42	48
Size of department/facility[4]								
Large ($200,000 or more)	100	10	55	35	100	4	48	47
Medium ($50,000-$199,999)	100	3	48	49	100	4	42	54
Small (Under $50,000)	100	13	32	55	100	15	30	55

[1]Statistical estimates encompass all research departments and all nondepartmental research facilities in the physical sciences, engineering and computer science at the 157 largest R&D universities in the U.S., except: (a) departments with no research instrument systems costing $10,000 or more, and (b) research installations consisting of interrelated components and subsystems costing over $1 million (large observatories, reactors, accelerators, etc.). Sample size = 353 departments/facilities.

[2]Includes materials science.

[3]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million; "N" indicates number of institutions in each size class.

[4]Classification based on reported FY1982 expenditures for research equipment.

NOTE: Sum of percents may not equal 100 because of rounding.

Table B-3. Department/facility recommendations for increased Federal support for research instrumentation, by field, type of university, and size of department/facility: National estimates, 1982[1]

Principal field of research in department/facility, type of university, and size of department/facility	Percent of departments/facilities recommending as top priority area for increased Federal support of academic research equipment:					
	Total[2]	Large scale facilities[3]	Systems in $50,000 - $1 million range[4]	Systems in $10,000 - $50,000 range[5]	Lab equipment under $10,000[6]	Other
Total, selected fields	100%	3%	36%	53%	7%	1%
Field						
Physical sciences, total	100	4	43	44	7	2
Chemistry	100	0	54	39	6	1
Physics and astronomy	100	8	31	50	7	4
Engineering, total	100	3	30	58	8	1
Electrical	100	11	50	24	15	0
Mechanical	100	2	30	64	0	3
Metallurgical/materials	100	0	62	29	9	0
Chemical	100	0	9	70	21	0
Civil	100	6	8	86	0	0
Other, n.e.c.	100	0	34	58	8	0
Computer science	100	0	30	70	0	0
Interdisciplinary, n.e.c.[7]	100	0	55	37	8	0
Type of university[8]						
Large private (N=11)	100	4	47	49	0	0
Large public (N=27)	100	3	40	48	6	3
Smaller private (N=42)	100	1	29	62	7	1
Smaller public (N=77)	100	3	34	53	9	0
Size of department/facility[9]						
Large ($200,000 or more)	100	4	47	37	10	2
Medium ($50,000-$199,999)	100	2	34	58	6	1
Small (Under $50,000)	100	1	26	68	5	0

[1]Statistical estimates encompass all research departments and all nondepartmental research facilities in the physical sciences, engineering and computer science at the 157 largest R&D universities in the U.S., except: (a) departments with no research instrument systems costing $10,000 or more and (b) research installations consisting of interrelated components and subsystems costing over $1 million (large observatories, reactors, accelerators, etc.). Sample size = 353 departments/facilities.

[2]Missing data are excluded; question had 12 percent nonusable response, largely the result of respondents checking more than one choice.

[3]"Large scale regional and national facilities (large telescopes, reactors, oceanographic vessels, high performance computers, etc.)"

[4]"Major shared access instrument systems ($50,000-$1,000,000) not presently available to department/facility members."

[5]"Upgrading/expansion of equipment in $10,000-$50,000 range."

[6]"General enhancement of equipment and supplies in labs of individual P.I.s (items generally below $10,000)."

[7]Includes materials science.

[8]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million; "N" indicates number of institutions in each size class.

[9]Classification is based on reported FY 1982 expenditures for research equipment.

NOTE: Sum of percents may not equal 100 because of rounding.

Table B-4. Number and cost of academic research instrument systems, by field and type of university: National estimates, 1982[1]

[Dollars in millions]

Principal field of research use and type of university	Number of systems	Percent Distribution	Aggregate Purchase cost[2]	Percent Distribution
Total, selected fields	24,348	100%	$990.2	100%
Field of research[3]				
Physical sciences, total	11,223	46	464.0	47
Chemistry	6,259	26	251.5	25
Physics and astronomy	4,964	20	212.5	22
Engineering, total	9,398	39	330.6	33
Electrical	2,377	10	86.4	9
Mechanical	1,884	8	68.2	7
Metallurgical/materials	1,117	5	42.1	4
Chemical	842	4	27.3	3
Civil	675	3	22.0	2
Other, n.e.c.	2,503	10	84.6	9
Computer science	1,024	4	57.9	6
Materials science	646	3	33.9	3
Interdisciplinary, n.e.c.	2,058	9	103.7	11
Type of university[4]				
Large private (N=11)	3,782	16	158.8	16
Large public (N=27)	8,630	35	365.8	37
Smaller private (N=42)	5,265	22	215.4	22
Smaller public (N=77)	6,670	27	250.1	25

[1]Statistical estimates refer to research instrument systems (including all dedicated accessories and components) originally costing $10,000-$1,000,000 in physical sciences, engineering, and computer science departments and facilities at the 157 largest R&D colleges and universities in the U.S. Estimates include systems used for research in 1982, existing components of research systems still under construction, and research systems that were inactive or inoperable throughout 1982. Equipment used or intended primarily for nonresearch purposes is excluded. Sample size = 3,428 systems.

[2]Manufacturer's list price at time of original purchase.

[3]For systems not used for research in 1982, classification based on name of cognizant department or facility.

[4]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million; "N" indicates number of institutions in each size class.

NOTE: Sum of percents may not equal 100 because of rounding.

Table B-5. Indices of academic research equipment intensiveness of major fields and subfields, 1982

Field[1]	Aggregate purchase cost of 1982 national stock of research equipment[2] [$ in millions]	Total academic R&D expenditures FY 1982[3] [$ in millions]	Research equipment cost as percent of total academic R&D expenditures FY 1982	Graduate student enrollment Fall 1982[4]	Research equipment cost per graduate student	Academic scientists/ engineers January 1983[5]	Research equipment cost per scientist/ engineer
Total, selected fields	$852.6	$1,920.9	44%	135,000	$ 7,300	84,800	$11,700
Chemistry	231.5	311.5	81	17,000	14,800	18,200	13,800
Physics and astronomy	212.5	436.6	49	10,700	19,900	14,600	14,600
Engineering, total	330.6	1,024.5	32	86,800	3,800	37,700	8,800
Electrical	86.4	224.3	39	22,000	3,900	9,600	9,000
Mechanical	68.2	141.5	48	11,600	5,900	6,700	10,200
Metallurgical/materials	42.1	-	-	4,100	10,300	-	-
Chemical	27.3	83.3	33	7,200	3,800	2,400	11,400
Civil	22.0	108.3	20	14,700	1,500	6,400	3,400
Computer science	57.9	148.3	39	20,300	2,900	14,300	4,000

[1]Table is limited to Phase I fields and subfields for which comparative data are available.

[2]From Table B-1.

[3]From Academic science/engineering: R&D funds, fiscal year 1982. Surveys of Science Resources Series, National Science Foundation, 1984 (GPO Publication No. NSF 84-308), p. B.

[4]From Academic science/engineering: Graduate enrollment and support, Fall 1982. Surveys of Science Resources Series, National Science Foundation, 1984 (GPO Publication No. NSF 84-306), p. 20.

[5]From Academic science/engineering: Scientists and engineers, January 1983. Surveys of Science Resources Series, National Science Foundation (GPO Publication No. NSF 84-309), p.7.

Table B-6. Mean number and cost per institution of academic research instrument systems, by field and by type of university: National estimates, 1982[1]

[Dollars in millions]

Principal field of research use[3]	Type of university[2]									
	Total (N=157)		Large private (N=11)		Large public (N=27)		Smaller private (N=42)		Smaller public (N=77)	
	Mean number of systems	Mean aggregate purchase cost	Mean number of systems	Mean aggregate purchase cost	Mean number of systems	Mean aggregate purchase cost	Mean number of systems	Mean aggregate purchase cost	Mean number of systems	Mean aggregate purchase cost
Total, selected fields	155.1	$6.3	343.8	$14.4	319.6	$13.5	125.3	$5.1	86.6	$3.2
Physical sciences, total	71.5	3.0	141.1	5.6	159.0	7.0	63.4	2.6	35.3	1.3
Chemistry	39.9	1.6	64.5	2.7	84.3	3.5	35.0	1.4	23.4	0.9
Physics and astronomy	31.6	1.4	76.6	2.9	74.7	3.5	28.4	1.2	11.8	0.4
Engineering, total	59.9	2.1	116.4	4.6	133.4	5.0	38.6	1.5	37.6	1.0
Electrical	15.1	0.6	40.9	2.1	36.3	1.3	5.1	0.2	9.5	0.2
Mechanical	12.0	0.4	19.5	0.7	23.6	1.0	16.6	0.6	4.4	0.1
Metallurgical/materials	7.1	0.3	15.0	0.5	17.9	0.8	2.2	0.1	4.9	0.1
Chemical	5.4	0.2	11.9	0.4	14.1	0.4	3.7	0.2	2.3	0.1
Civil	4.3	0.1	6.0	0.2	12.1	0.5	0.7	*	3.3	0.1
Other, n.e.c*	15.9	0.5	23.0	0.8	29.4	1.1	10.3	0.4	13.3	0.4
Computer science	6.5	0.4	34.6	2.2	5.7	0.3	6.6	0.3	2.8	0.1
Materials science	4.1	0.2	25.5	1.2	5.6	0.3	3.4	0.2	0.9	*
Interdisciplinary, n.e.c	13.1	0.7	26.3	0.8	15.9	0.8	13.4	0.4	10.1	0.7

[1]Statistical estimates refer to research instrument systems (including all dedicated accessories and components) originally costing $10,000–$1,000,000 in physical science, engineering, and computer science departments and facilities at the 157 largest R&D colleges and universities in the U.S. Estimates include systems used for research in 1982, existing components of research systems still under construction, and research systems that were inactive or inoperable through 1982. Equipment used or intended primarily for nonresearch purposes is excluded. Sample size = 3,428 systems.

[2]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $28–32.9 million; "N" indicates number of institutions in each size class.

[3]For systems not used for research in 1982, classification based on name of cognizant department or facility.

Table B-7. Distribution of academic research instrument systems, by field and type of university and by system cost range: National estimates, 1982[1]

Principal field of research use and type of university	Number of systems	Percent of systems, by system cost range			
		Total	$10,000 - $24,999	$25,000 - $74,999	$75,000 $1,000,000
Total, selected fields	24,348	100%	57%	32%	11%
Field of research[2]					
Physical sciences, total	11,223	100	55	33	13
Chemistry	6,259	100	56	31	13
Physics and astronomy	4,964	100	53	35	13
Engineering, total	9,398	100	62	30	8
Electrical	2,377	100	61	30	9
Mechanical	1,884	100	64	28	9
Metallurgical/materials	1,117	100	53	36	11
Chemical	842	100	56	37	7
Civil	675	100	68	23	9
Other, n.e.c.	2,503	100	64	30	7
Computer science	1,024	100	43	43	14
Materials science	646	100	52	30	17
Interdisciplinary, n.e.c.	2,058	100	62	26	12
Type of university[3]					
Large private (N=11)	3,782	100	58	32	10
Large public (N=27)	8,630	100	57	30	13
Smaller private (N=42)	5,625	100	54	33	12
Smaller public (N=77)	6,670	100	60	32	8

[1]Statistical estimates refer to research instrument systems (including all dedicated accessories and components) originally costing $10,000-$1,000,000 in physical science, engineering, and computer science departments and facilities at the 157 largest R&D colleges and universities in the U.S. Estimates include systems used for research in 1982, existing components of research systems still under construction, and research systems that were inactive or inoperable throughout 1982. Equipment used or intended primarily for nonresearch purposes is excluded. Sample size = 3,428 systems.

[2]For systems not used for research in 1982, classification is based on name of cognizant department or facility.

[3]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million; "N" indicates number of institutions in each size class.

NOTE: Sum of percents may not equal 100 because of rounding.

Table B-8. Distribution of aggregate purchase cost of academic research instrument systems, by field and type of university and by system cost range: National estimates, 1982.[1]

[Dollars in in millions]

Principal field of research use and type of university	Aggregate purchase cost[2]	Percent of aggregate purchase cost, by system cost range			
		Total	$10,000 - $24,999	$25,000 - $74,999	$75,000 - $1,000,000
Total selected fields	$990.2	100%	22%	32%	46%
Field of research[3]					
Physical sciences, total	464.0	100	21	32	47
Chemistry	251.5	100	22	32	46
Physics and astronomy	212.5	100	19	32	49
Engineering, total	330.6	100	27	34	39
Electrical	86.4	100	26	33	41
Mechanical	68.2	100	28	30	42
Metallurgical/materials	42.1	100	24	37	40
Chemical	27.3	100	27	49	24
Civil	22.0	100	31	28	41
Other, n.e.c.	84.6	100	28	34	38
Computer science	57.9	100	12	30	58
Materials science	33.9	100	15	28	56
Interdisciplinary, n.e.c.	103.7	100	19	24	57
Type of university[4]					
Large private (N=11)	158.8	100	22	30	48
Large public (N=27)	365.8	100	21	29	51
Smaller private (N=42)	215.4	100	20	35	45
Smaller public (N=77)	250.1	100	26	34	40

[1]Statistical estimates refer to research instrument systems (including all dedicated accessories and components) originally costing $10,000-$1,000,000 in physical science, engineering, and computer science departments and facilities at the 157 largest R&D colleges and universities in the U.S. Estimates include systems used for research in 1982, existing components of research systems still under construction, and research systems that were inactive or inoperable throughout 1982. Equipment used or intended primarily for nonresearch purposes is excluded. Sample size = 3,428 systems.

[2]Manufacturer's list price at time of original purchase.

[3]For systems not used for research in 1982, classification based on name of cognizant department or facility.

[4]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million; "N" indicates number of institutions in each size class.

NOTE: Sum of percents may not equal 100 because of rounding.

Table B-9. Research status of academic research instrument systems, by field and type of university: National estimates, 1982[1]

Principal field of research use and type of university	Number of systems	Percent of systems, by research status				
			In active research use		Not yet in research use	No longer in research use
		Total	State-of-the-art	Other		
Total, selected fields	24,348	100%	16%	56%	2%	26%
Field of research[2]						
Physical sciences, total	11,223	100	15	60	1	24
Chemistry	6,259	100	14	63	1	22
Physics and astronomy	4,964	100	16	58	2	25
Engineering, total	9,398	100	18	55	3	24
Electrical	2,377	100	18	51	1	30
Mechanical	1,884	100	19	54	4	23
Metallurgical/materials	1,117	100	14	76	2	8
Chemical	842	100	17	64	0	19
Civil	675	100	14	45	16	25
Other, n.e.c.	2,503	100	22	48	2	28
Computer science	1,024	100	17	60	6	17
Materials science	646	100	16	74	0	10
Interdisciplinary, n.e.c.	2,058	100	11	36	1	52
Type of university[3]						
Large private (N=11)	3,782	100	18	61	3	17
Large public (N=27)	8,630	100	14	58	2	26
Smaller private (N=42)	5,265	100	14	51	2	33
Smaller public (N=87)	6,670	100	19	55	2	24

[1]Statistical estimates refer to research instrument systems (including all dedicated accessories and components) originally costing $10,000-$1,000,000 in physical science, engineering, and computer science departments and facilities at the 157 largest R&D colleges and universities in the U.S. Estimates include systems used for research in 1982, existing components of research systems still under construction, and research systems that were inactive or inoperable throughout 1982. Equipment used or intended primarily for nonresearch purposes is excluded. Sample size = 3,428 systems.

[2]For systems not used for research in 1982, classification is based on name of cognizant department or facility.

[3]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $28 - 32.9 million; "N" indicates number of institutions in each size class.

NOTE: Sum of percents may not equal 100 because of rounding.

Table B-10. Number and aggregate cost/value of academic research instrument systems in active research use, by field and type of university: National estimates, 1982.[1]

[Dollars in millions]

Principal field of research use and type of university	Number of systems	Index of aggregate cost/value			
		Purchase cost[2]	Acquisition cost[3]	Replacement value[4]	1982 cost-equivalent[5]
Total, selected fields	17,586	$758.1	$703.2	$1,133.7	$1,162.8
Field of research					
Physical sciences, total	8,424	373.6	353.2	529.3	610.2
Chemistry	4,791	210.4	201.1	295.0	331.7
Physics and astronomy	3,633	163.2	152.1	234.3	278.4
Engineering, total	6,829	259.4	232.4	413.3	374.6
Electrical	1,650	66.4	56.0	92.2	89.0
Mechanical	1,363	50.9	47.8	95.5	66.9
Metallurgical/materials	998	39.0	36.6	65.2	60.9
Chemical	682	23.3	22.8	28.6	32.3
Civil	397	14.1	13.9	22.4	21.6
Other, n.e.c.	1,739	65.7	55.3	109.0	104.0
Computer science	788	48.5	44.9	57.7	57.7
Materials science	581	31.5	31.2	61.7	53.6
Interdisciplinary, n.e.c.	965	45.0	41.3	71.0	67.8
Type of university[6]					
Large private (N=11)	3,014	134.0	125.9	205.4	185.2
Large public (N=27)	6,234	285.5	264.4	434.7	447.7
Smaller private (N=42)	3,426	157.9	146.6	221.0	236.5
Smaller public (N=77)	4,911	180.6	166.0	273.1	293.3

[1]Statistical estimates refer to research instrument systems (including all dedicated accessories and components) originally costing $10,000-$1,000,000 in physical science, engineering, and computer science departments and facilities at the 157 largest R&D colleges and universities in the U.S. Estimates limited to systems used for research in 1982. Sample size = 2,582 systems.

[2]Manufacturer's list price at time of original purchase.

[3]Actual cost to acquire instrument system at this university, including transportation and construction/labor costs.

[4]User estimate of 1982 cost of same or functionally equivalent equipment.

[5]Original purchase cost converted to 1982 dollars using Machinery and Equipment Index of the Bureau of Labor Statistics' Annual Producer Price Index to adjust for inflation.

[6]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million; "N" indicates number of institutions in each size class.

Table B-11. Mean number and cost per institution of academic research instrument systems in active research use, by field and by type of university: National estimates, 1982[1]

[Dollars in millions]

Principal field of research	Type of university[2]									
	Total (N=157)		Large private (N=11)		Large public (N=27)		Smaller private (N=42)		Smaller public (N=77)	
	Mean number of systems	Mean aggregate purchase cost	Mean number of systems	Mean aggregate purchase cost	Mean number of systems	Mean aggregate purchase cost	Mean number of systems	Mean aggregate purchase cost	Mean number of systems	Mean aggregate purchase cost
Total, selected fields	112.0	$4.83	274.0	$12.18	230.9	$10.57	81.6	$3.76	63.8	$2.35
Physical sciences, total	53.7	2.38	117.1	4.86	120.3	5.68	42.0	1.87	27.6	1.15
Chemistry	30.5	1.34	52.4	2.33	68.7	3.07	22.0	1.03	18.6	0.76
Physics and astronomy	23.1	1.04	52.4	2.54	51.6	2.62	19.9	0.83	9.0	0.39
Engineering, total	43.5	1.65	91.5	3.82	91.2	3.71	27.4	1.26	28.7	0.84
Electrical	10.5	0.42	32.8	1.63	27.4	1.12	2.7	0.17	5.6	0.15
Mechanical	8.7	0.32	17.3	0.64	13.6	0.57	14.2	0.50	2.7	0.10
Metallurgical/materials	6.4	0.25	12.8	0.46	14.9	0.69	2.2	0.13	4.7	0.13
Chemical	4.3	0.15	11.6	0.37	10.6	0.33	3.2	0.17	1.7	0.04
Civil	2.5	0.09	3.2	0.15	8.0	0.30	0.5	0.02	1.6	0.04
Other, n.e.c.	11.1	0.42	13.8	0.57	16.6	0.69	4.6	0.27	12.3	0.38
Computer science	5.0	0.31	25.3	1.82	3.7	0.26	5.7	0.31	2.2	0.1
Materials science	3.7	0.20	24.1	1.10	3.9	0.28	3.3	0.19	0.9	0.05
Interdisciplinary, n.e.c.	6.1	0.28	16.0	1.10	11.9	0.64	3.3	0.13	4.3	0.21

[1]Statistical estimates refer to research instrument systems (including all dedicated accessories and components) originally costing $10,000-$1,000,000 in physical science, engineering, and computer science departments and facilities at the 157 largest R&D colleges and universities in the U.S. Estimates limited to systems actually used for research in 1982. Sample size = 2,582 systems.

[2]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million; "N" indicates number of institutions in each size class.

Table B-12. Instrumentation-related expenditures in academic departments and facilities, by field and type of university: National estimates, FY 1982[1]

[Dollars in millions]

Principal field of research in department/facility and type of university	FY 1982 expenditures			
	Total	Purchase of research equipment[2]	Purchase of research-related computer services[3]	Maintenance/repair of research equipment[4]
Total, selected fields	$375.6	$231.0	$84.7	$60.0
Field of research				
Physical sciences, total	156.6	94.5	33.9	28.2
Chemistry	73.7	39.6	23.3	10.8
Physics and astronomy	83.7	55.2	10.9	17.6
Engineering, total	154.4	90.9	43.9	19.6
Electrical	52.9	36.2	11.5	5.2
Mechanical	23.0	8.7	10.8	3.5
Metallurgical/materials	9.4	7.4	0.8	1.2
Chemical	15.8	7.8	5.7	2.3
Civil	16.4	9.6	5.4	1.4
Other, n.e.c.	36.7	21.3	9.5	5.9
Computer science	30.9	20.0	4.3	6.6
Interdisciplinary, n.e.c.[5]	33.7	25.6	2.6	5.5
Type of university[6]				
Large private (N=11)	74.8	51.9	9.8	13.1
Large public (N=27)	128.8	74.6	33.4	20.8
Smaller private (N=42)	68.7	46.0	11.3	11.4
Smaller public (N=77)	108.8	63.1	29.3	16.4

[1]Statistical estimates encompass all research departments and all nondepartmental research facilities in the physical sciences, engineering and computer science at the 157 largest R&D universities in the U.S., except: (a) departments with no research instrument systems costing $10,000 or more and (b) research installations consisting of interrelated components costing over $1 million (large observatories, reactors, accelerators, etc.). Sample size = 353 departments/facilities.

[2]Estimates refer to expenditures for nonexpendable, tangible property or software having a useful life of more than two years and an acquisition cost of $500 or more, used wholly or in part for scientific research.

[3]Estimates refer to purchase of computer services at on-campus and off-campus facilities but not to purchase of computer hardware or software.

[4]Estimates encompass expenditures for service contracts, field service, salaries of maintenance/repair personnel, and other direct costs of supplies, equipment and facilities for servicing of research instruments.

[5]Includes materials science.

[6]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million; "N" indicates number of institutions in each size class.

Table B-13. Expenditures for purchase of research equipment, by field and type of university: National estimates, FY 1982 (actual) and FY 1983 (anticipated)[1]

[Dollars in millions]

Principal field of research in department/facility and type of university	Expenditures for purchase of research equipment[2]		
	FY 1982 (actual)	FY 1983 (anticipated)	Percent change, FY 1982-83
Total, selected fields	$227.6	$264.6	16%
Field of research			
Physical sciences, total	94.5	102.8	9
Chemistry	39.6	42.7	8
Physics and astronomy	55.1	60.5	10
Engineering, total	90.8	101.8	13
Electrical	36.1	42.2	17
Mechanical	8.7	10.5	21
Metallurgical/materials	7.5	5.3	29
Chemical	7.9	8.9	13
Civil	9.6	10.3	7
Other, n.e.c.	21.3	25.1	18
Computer science	20.0	35.4	77
Interdisciplinary, n.e.c.[3]	22.6	24.1	7
Type of university[4]			
Large private (N=11)	50.2	58.0	16
Large public (N=27)	72.9	83.3	14
Smaller private (N=42)	46.0	56.7	23
Smaller public (N=77)	61.9	69.9	13

[1]Statistical estimates encompass all research departments and all nondepartmental research facilities in the physical sciences, engineering and computer science at the 157 largest R&D universities in the U.S., except: (a) departments with no research instrument systems costing $10,000 or more and (b) research installations consisting of interrelated components costing over $1 million (large observatories, reactors, accelerators, etc.). Sample size = 353 departments/facilities.

[2]Estimates refer to expenditures for nonexpendable, tangible property or software having a useful life of more than two years and an acquisition cost of $500 or more, used wholly or in part for scientific research.

[3]Includes materials science.

[4]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million; "N" indicates number of institutions in each size class.

Table B-14. Factors associated with department/facility expenditures for purchase of research equipment: National estimates, FY 1982[1]

Factor	Number of departments/ facilities	Percent of departments/facilities, by range of FY 1982 expenditures for research equipment[2]			
		Total	Under $50,000	$50,000-$199,000	$200,000 or more
Total, selected fields	1,205	100%	32%	34%	34%
No. of Ph.D.'s awarded, 1981-82 academic year (departments only)					
0-4	666	100	43	33	24
5-9	191	100	20	52	29
10+	214	100	6	25	69
No. of faculty-level researchers, 1981-82 academic year (departments only)					
1-9	198	100	73	25	2
10-19	493	100	36	41	22
20+	381	100	5	34	61
Type of entity					
Academic department	1,068	100	31	36	33
Nondepartmental research facility	137	100	33	23	44
Field of research					
Chemistry	177	100	10	55	35
Physics and astronomy	194	100	21	34	46
Engineering	657	100	44	28	28
Computer science	91	100	12	51	38
Interdisciplinary, n.e.c.[3]	86	100	29	20	51
Type of university[4]					
Large private (N=11)	106	100	9	28	62
Large public (N=27)	322	100	25	37	38
Smaller private (N=42)	259	100	25	34	41
Smaller public (N=77)	518	100	44	33	23

[1]Statistical estimates encompass all research departments and all nondepartmental research facilities in the physical sciences, engineering and computer science at the 157 largest R&D universities in the U.S., except: (a) departments with no research instrument systems costing $10,000 or more and (b) research installations consisting of interrelated components costing over $1 million (large observatories, reactors, accelerators, etc.). Sample size = 353 departments/facilities.

[2]Estimates refer to expenditures for nonexpendable, tangible property or software having a useful life of more than two years and an acquisition cost of $500 or more, used wholly or in part for scientific research.

[3]Includes materials science.

[4]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million; "N" indicates number of institutions in each size class.

NOTE: Sum of percents may not equal 100 because of rounding.

Table B-15. Mean expenditures for purchase of research equipment, by field and type of university and by unit: National estimates, FY 1982[1]

Principal field of research in department/facility and type of university	Mean FY 1982 expenditures for research equipment:[2]		
	Per university	Per department/facility	Per faculty-level researcher
Total, selected fields	$1,450,000	$189,000	$10,000
Field of research			
Physical sciences, total	602,000	255,000	10,600
Chemistry	252,000	224,000	11,100
Physics and astronomy	351,000	284,000	10,300
Engineering, total	578,000	138,200	7,600
Electrical	230,000	384,000	16,600
Mechanical	56,000	79,000	4,[illegible]
Metallurgical/materials	48,000	159,000	13,[illegible]
Chemical	50,000	95,000	2,800
Civil	61,000	91,000	4,500
Other, n.e.c.	136,000	98,000	5,300
Computer science	128,000	220,000	11,700
Interdisciplinary, n.e.c.[3]	144,000	263,000	*
Type of university[4]			
Large private (N=11)	4,565,000	473,700	16,100
Large public (N=27)	2,700,000	226,400	9,600
Smaller private (N=42)	1,096,000	177,800	9,900
Smaller public (N=77)	804,000	119,600	8,400

[1]Statistical estimates encompass all research departments and all nondepartmental research facilities in the physical sciences, engineering and computer science at the 157 largest R&D universities in the U.S., except: (a) departments with no research instrument systems costing $10,000 or more and (b) research installations consisting of interrelated components costing over $1 million (large observatories, reactors, accelerators, etc.). Sample size = 353 departments/facilities.

[2]Estimates refer to expenditures for nonexpendable, tangible property or software having a useful life of more than two years and an acquisition cost of $500 or more, used wholly or in part for scientific research.

[3]Includes materials science.

[4]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million; "N" indicates number of institutions in each size class.

*A meaningful per faculty mean cannot be computed for interdisciplinary research facilities, most of which are not departments. Faculty data were obtained only from departments.

Table 6-16. Age distribution of academic research instrument systems, by field and type of university: National estimates, 1982[1]

Principal field of research use and type of university	Percent of systems, by system age (from year of purchase)			
	Total	1-5 years (1978-82)	6-10 years (1973-77)	Over 10 years (1972 or before)
Total, selected fields	100%	49%	20%	31%
Field of research[2]				
Physical sciences, total	100	45	21	34
Chemistry	100	49	22	29
Physics and astronomy	100	40	20	40
Engineering, total	100	53	18	29
Electrical	100	65	17	19
Mechanical	100	49	13	38
Metallurgical/materials	100	63	16	21
Chemical	100	56	23	21
Civil	100	50	13	37
Computer science	100	78	9	12
Materials science	100	34	14	52
Interdisciplinary, n.e.c.	100	40	28	33
Type of university[3]				
Large private (N=11)	100	61	19	20
Large public (N=27)	100	49	23	28
Smaller private (N=42)	100	42	16	42
Smaller public (N=77)	100	48	20	32

[1]Statistical estimates refer to research instrument systems (including all dedicated accessories and components) originally costing $10,000-$1,000,000 in physical science, engineering, and computer science departments and facilities at the 157 largest R&D colleges and universities in the U.S. Estimates include systems used for research in 1982, existing components of research systems still under construction, and research systems that were inactive or inoperable through 1982. Equipment used or intended primarily for nonresearch purposes is excluded. Sample size = 3,428 systems.

[2]For systems not used for research in 1982, classification is based on name of cognizant department or facility.

[3]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million; "N" indicates number of institutions in each size class.

NOTE: Sum of percents may not equal 100 because of rounding.

Table B-17. Percent of academic research instrument systems that are classified as state-of-the-art, by field and type of university and by purchase cost: National estimates, 1982[1]

Principal field of research use and type of university	Percent of systems classified as state-of-the-art[2] by purchase cost range			
	Total	$10,000 - $24,999	$25,000- $74,999	$75,000- $1,000,000
Total, selected fields	16%	13%	17%	24%
Field of research[3]				
Physical sciences, total	14	11	16	22
Chemistry	14	13	12	21
Physics and astronomy	15	9	22	24
Engineering, total	18	17	17	30
Electrical	18	16	19	30
Mechanical	19	20	16	20
Metallurgical/materials	14	12	17	16
Chemical	16	13	13	70
Civil	14	8	14	33
Other, n.e.c.	22	22	17	16
Computer science	18	9	26	18
Materials science	16	6	25	31
Interdisciplinary, n.e.c.	11	8	14	18
Type of university[4]				
Large private (N=11)	18	12	28	29
Large public (N=27)	14	10	17	25
Smaller private (N=42)	14	13	12	22
Smaller public (N=77)	19	19	18	20

[1]Statistical estimates refer to research instrument systems (including all dedicated accessories and components) originally costing $10,000-$1,000,000 in physical science, engineering, and computer science departments and facilities at the 157 largest R&D colleges and universities in the U.S. Estimates include systems used for research in 1982, existing components of research systems still under construction, and research systems that were inactive or inoperable through 1982. Equipment used or intended primarily for nonresearch purposes is excluded. Sample size = 3,428 systems.

[2]From user classification of "Technical capabilities of this instrument (i.e., the base instrument, excluding accessories)" as "state-of-the-art (most highly developed and scientifically sophisticated instrument available)."

[3]For systems not used for research in 1982, classification is based on name of cognizant department or facility.

[4]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $26-32.9 million; "N" indicates number of institutions in each size class.

NOTE: Sum of percents may not equal 100 because of rounding.

Table B-18. Percent of academic research instrument systems that are classified as state-of-the-art, by field and type of university and by year of purchase: National estimates, 1982[1]

Principal field of research use and type of university	Percent of systems classified as state-of-the-art,[2] by year of purchase							
	Total	1982	1981	1980	1979	1978	1973-77	Before 1973
Total, selected fields	16%	38%	32%	27%	18%	12%	11%	4%
Field of research[3]								
Chemistry	14	34	19	37	20	9	8	0
Physics and astronomy	15	31	41	28	27	18	12	4
Engineering	18	43	35	25	17	12	9	7
Computer science	18	39	16	5	12	4	4	0
Interdisciplinary, n.e.c.[4]	12	41	32	18	12	10	23	0
Type of university[5]								
Large private (N=11)	18	57	31	18	16	11	8	1
Large public (N=27)	14	26	31	27	17	13	8	2
Smaller private (N=42)	14	40	45	13	18	14	11	1
Smaller public (N=77)	18	42	28	38	22	10	15	9

[1]Statistical estimates refer to research instrument systems (including all dedicated accessories and components) originally costing $10,000-$1,000,000 in physical science, engineering, and computer science departments and facilities at the 157 largest R&D colleges and universities in the U.S. Estimates include systems used for research in 1982, existing components of research systems still under construction, and research systems that were inactive or inoperable through 1982. Equipment used or intended primarily for nonresearch purposes is excluded. Sample size = 3,428 systems.

[2]From user classification of "Technical capabilities of this instrument (i.e., the base instrument, excluding accessories)" as "state-of-the-art (most highly developed and scientifically sophisticated instrument available)."

[3]For systems not used for research in 1982, classification is based on name of cognizant department or facility.

[4]Includes materials science.

[5]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million; "N" indicates number of institutions in each size class.

NOTE: Sum of percents may not equal 100 because of rounding.

Table B-19. Age distribution of state-of-the-art academic research instrument systems by field and type of university: National estimates, 1982[1]

Principal field of research use and type of university	Percent of state-of-the-art systems, by system age (from year of purchase)			
	Total	1-5 years (1978-82)	6-10 years (1973-77)	Over 10 years (1972 or before)
Total, selected fields	100%	80%	13%	7%
Field of research				
Physical sciences, total	100	81	14	5
Chemistry	100	86	13	1
Physics and astronomy	100	75	16	9
Engineering, total	100	80	9	11
Electrical	100	96	2	2
Mechanical	100	94	6	0
Metallurgical/materials	100	92	6	2
Chemical	100	92	4	2
Civil	100	89	3	8
Other, n.e.c.	100	50	20	30
Computer science	100	98	2	0
Materials science	100	75	24	1
Interdisciplinary, n.e.c.	100	53	46	1
Type of university[2]				
Large private (N=11)	100	90	10	0
Large public (N=27)	100	81	13	5
Smaller private (N=42)	100	84	13	3
Smaller public (N=77)	100	71	15	14

[1]Statistical estimates refer to research instrument (including all dedicated accessories and components) originally costing $10,000-$1,000,000 in physical science, engineering and computer science departments and facilities at the 157 largest R&D universities in the U.S. Estimates limited to instrument systems in research use in 1982 that were classified by the principal user as state-of-the-art at the time of the survey (early 1983). Sample size = 614 instrument systems.

[2]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million; "N" indicates number of institutions in each size class.

NOTE: Sum of percents may not equal 100 because of rounding.

Table B-20. Median age of academic research instrument systems, by field and type of university and by research status: National estimates, 1982[1]

Principal field of research use and type of university	Median age (in years)[2] by 1982 research status				
	Total	In research use		Not yet in research use	No longer in research use
		State-of the-art	Other		
Total	6	3	5	2	12
Field of research[3]					
Physical sciences, total	6	3	6	3	12
Chemistry	6	3	5	1	12
Physics and astronomy	8	3	7	3	13
Engineering, total	5	3	5	1	12
Electrical	4	2	4	1	8
Mechanical	6	1	6	3	12
Metallurgical/materials	4	3	4	2	11
Chemical	5	2	5	1	9
Civil	6	3	7	2	12
Other, n.e.c.	8	6	8	2	10
Computer science	3	1	3	1	12
Materials science	11	2	12	1	15
Interdisciplinary, n.e.c.	8	5	5	1	14
Type of University[4]					
Large private (N=11)	4	2	4	2	12
Large public (N=27)	6	3	6	1	11
Smaller private (N-42)	9	2	7	3	15
Smaller public (N=77)	6	3	6	1	11

[1]Statistical estimates refer to research instrument systems (including all dedicated accessories and components) originally costing $10,000-$1,000,000 in physical science, engineering, and computer science departments and facilities at the 157 largest R&D colleges and universities in the U.S. Estimates include systems used for research in 1982, existing components of research systems still under construction, and research systems that were inactive or inoperable through 1982. Equipment used or intended primarily for nonresearch purposes is excluded. Sample size = 3,428 systems.

[2]Age measured in years, based on year of purchase, with all 1982 purchases = 1 year of age; all 1981 items = 2 years of age; etc.

[3]For systems not used for research in 1982, classification based on name of cognizant department or facility.

[4]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million; "N" indicates number of institutions in each size class.

Table B-21. Condition of academic research instrument systems in use, by system age: National estimates, 1982[1]

System age (from year of purchase)	Percent of systems, by general working condition			
	Total	Excellent	Average	Poor
Total, selected fields	100%	51%	37%	11%
1-5 years (1978-82)	100	67	28	5
6-10 years (1973-77)	100	37	49	13
11-15 years (1968-72)	100	27	47	26
16+ years (1967 or before)	100	22	53	25

[1]Statistical estimates refer to research instrument systems (including all dedicated accessories and components) originally costing $10,000-$1,000,000 in physical science, engineering, and computer science departments and facilities at the 157 largest R&D colleges and universities in the U.S. Estimates limited to systems used for research in 1982. Sample size = 2,582 systems.

NOTE: Sum of percents may not equal 100 because of rounding.

Table 8-22. Distribution of academic research instrument systems in use that were in excellent working condition, by field and type of university and by research status: National estimates, 1982[1]

Principal field of research use and type of university	Percent of systems in excellent working condition,[2] by 1982 research status		
	Total	State-of-the-art systems	Other systems
Total, selected fields	51%	84%	42%
Field of research			
Physical sciences, total	52	84	44
Chemistry	51	88	43
Physics and astronomy	53	80	46
Engineering, total	51	85	40
Electrical	54	92	41
Mechanical	53	83	43
Metallurgical/materials	57	85	52
Chemical	39	78	29
Civil	38	76	26
Other, n.e.c.	52	83	38
Computer science	59	89	50
Materials science	32	76	23
Interdisciplinary, n.e.c.	46	74	38
Type of university[3]			
Large private (N=11)	52	87	41
Large public (N=27)	52	86	44
Smaller private (N=42)	51	74	45
Smaller public (N=77)	49	86	37

[1]Statistical estimates refer to research instrument systems (including all dedicated accessories and components) originally costing $10,000-$1,000,000 in physical science, engineering, and computer science departments and facilities at the 157 largest R&D colleges and universities in the U.S. Estimates limited to systems used for research in 1982. Sample size = 2,582 systems.

[2]Based on user characterization.

[3]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million; "N" indicates number of institutions in each size class.

NOTE: Sum of percents may not equal 100 because of rounding.

Table B-23. Distribution of in-use academic research instrument systems that are the "most advanced instrument of its kind accessible to its research users," by field and type of university and by research status: National estimates, 1982[1]

Principal field of research use and type of university	Percent of in-use systems that are the most advanced accessible to their users,[2] by 1982 research status		
	Total	State-of-the-art systems	Other systems
Total, selected fields	59%	96%	49%
Field of research			
Physical sciences, total	58	97	49
Chemistry	61	98	52
Physics and astronomy	55	96	44
Engineering, total	61	98	52
Electrical	54	93	41
Mechanical	62	95	50
Metallurgical/materials	59	97	51
Chemical	60	96	50
Civil	53	94	41
Other, n.e.c.	70	98	58
Computer science	66	99	56
Materials science	43	100	30
Interdisciplinary, n.e.c.	67	98	58
Type of university[3]			
Large private (N=11)	54	96	41
Large public (N=27)	53	95	43
Smaller private (N=42)	63	95	54
Smaller public (N=77)	68	98	58

1Statistical estimates refer to research instrument systems (including all dedicated accessories and components) originally costing $10,000-$1,000,000 in physical science, engineering, and computer science departments and facilities at the 157 largest R&D colleges and universities in the U.S. Estimates limited to systems used for research in 1982. Sample size = 2,582 systems.

2Alternative to this classification is "system used for research, but more advanced instruments are available to users when needed."

3"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million; "N" indicates number of institutions in each size class.

NOTE: Sum of percents may not equal 100 because of rounding.

Table B-24. Number and cost/value of academic research instrument systems in use, by means of acquisition: National estimates, 1982[1]

Statistic	Means of acquisition of instrument system							
	Total	Purchased new	Locally built	Purchased used	Donated		Govt. surplus	Other
					New	Used		
Number of systems	17,586	14,816	759	747	386	227	356	296
Total:			[Dollars in millions]					
Purchase cost[2]	$ 758.1	$ 630.3	$ 38.6	$27.8	$16.2	$13.4	$17.7	$14.2
Acquisition cost[3]	703.2	622.3	40.7	26.9	2.0	1.1	1.6	7.4
Replacement cost[4]	1133.7	904.9	78.1	53.5	20.0	22.0	31.3	24.4
1982 cost-equivalent[5]	1162.8	977.7	47.8	45.8	20.1	18.8	26.9	25.7
Mean per system:			[Dollars in thousands]					
Purchase cost[2]	43.1	42.5	50.9	37.2	42.1	59.0	49.7	48.0
Acquisition cost[3]	40.0	42.0	53.6	36.0	5.3	4.9	4.4	25.1
Replacement cost[4]	64.5	61.1	102.9	71.6	51.9	100.8	87.9	82.6
1982 cost-equivalent[5]	66.1	66.0	63.0	61.3	52.2	82.6	75.6	86.8

[1]Statistical estimates refer to research instrument systems (including all dedicated accessories and components) originally costing $10,000-$1,000,000 in physical science, engineering, and computer science departments and facilities at the 157 largest R&D colleges and universities in the U.S. Estimates limited to systems used for research in 1982. Sample size = 2,582 systems.

[2]Manufacturer's list price at time of original purchase.

[3]Actual cost to acquire instrument system of this university, including transportation and construction/labor costs.

[4]User estimates of 1982 cost of same or functionally equivalent equipment.

[5]Original purchase cost converted to 1982 dollars using Machinery and Equipment index of the Bureau of Labor Statistics' Annual Producer Price Index to adjust for inflation.

Table B-25. Acquisition of academic research instrument systems in use, by field and type of university and by source of funds: National estimates, 1982[1]

Principal field of research use, and type of university	Percent of aggregate acquisition cost,[2] by funding source									
		Federal					Non-Federal			
	Total	NSF	NIH	DOD	DOE	Other	Univ.	State	Industry	Other[3]
Total	100%	27%	4%	14%	7%	6%	29%	5%	4%	5%
Field of research										
Physical sciences, total	100	34	5	9	9	8	27	2	1	5
Chemistry	100	36	9	4	3	2	37	3	2	5
Physics and astronomy	100	31	1	16	17	16	14	0	0	5
Engineering, total	100	16	1	22	6	4	36	6	6	3
Electrical	100	21	3	38	6	2	21	2	5	2
Mechanical	100	16	0	27	6	2	29	4	11	5
Metallurgical/materials	100	18	0	6	11	9	26	18	6	6
Chemical	100	26	1	25	5	5	24	4	8	1
Civil	100	12	0	1	3	2	62	10	5	4
Other, n.e.c.	100	7	2	16	5	3	60	3	2	2
Computer science	100	22	1	17	0	3	27	11	17	2
Materials science	100	41	2	16	10	4	16	8	2	0
Interdisciplinary, n.e.c.	100	24	9	13	4	4	22	8	4	13
Type of university										
Large private (N=11)	100	35	6	21	5	7	17	0	5	4
Large public (N=27)	100	26	5	11	11	6	32	4	4	2
Smaller private (N=42)	100	32	2	21	3	5	25	0	1	5
Smaller public (N=77)	100	17	2	9	5	6	37	12	2	8

[1]Statistical estimates refer to research instrument systems (including all dedicated accessories and components) originally costing $10,000-$1,000,000 in physical science, engineering, and computer science departments and facilities at the 157 largest R&D colleges and universities in the U.S. Estimates limited to systems used for research in 1982. Sample size = 2,582 systems.

[2]Actual cost to acquire instrument system at this university, including transportation and construction/labor costs.

[3]Individuals and nonprofit organizations.

NOTE: Sum of percents may not equal 100 because of rounding.

Table 8-26. Percent of aggregate acquisition cost of in-use academic research instrument systems that was contributed by Federal funding sources, by field and type of university and by system acquisition cost range: National estimates, 1982[1]

Principal field of research use and type of university	Percent of aggregate acquisition cost from Federal sources, by system acquisition cost range[2]			
	Total	$10,000-$24,999	$25,000 $74,999	$75,000-$1,000,000,000
Total	58%	57%	57%	58%
Field of research				
Physical sciences, total	65	62	68	64
Chemistry	54	48	55	55
Physics and astronomy	80	84	83	77
Engineering total	49	51	46	50
Electrical	70	76	78	58
Mechanical	51	66	27	60
Metallurgical/materials	44	40	42	48
Chemical	62	54	71	54
Civil	19	11	29	15
Other, n.e.c.	32	25	27	41
Computer science	43	34	41	45
Materials science	73	94	63	74
Interdisciplinary, n.e.c.	53	56	46	55
Type of university[3]				
Large private(N=11)	73	77	72	72
Large public (N=27)	59	59	59	59
Smaller private (N=42)	63	70	60	63
Smaller public (N=77)	41	34	47	39

[1]Statistical estimates refer to research instrument systems (including all dedicated accessories and components) originally costing $10,000-$1,000,000 in physical science, engineering, and computer science departments and facilities at the 157 largest R&D colleges and universities in the U.S. Estimates limited to systems used for research in 1982. Sample size = 2,582 systems.

[2]Actual cost to acquire instrument system at this university, including transportation and construction/labor costs.

[3]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million; "N" indicates number of institutions in each size class.

NOTE: Sum of percents may not equal 100 because of rounding.

Table B-27. Federal involvement in funding of academic research instrument systems in use, by field and type of university: National estimates, 1982[1]

Principal field of research use and type of university	Percent of systems, by Federal funding involvement			
	Total	No Federal funding	Partial Federal funding	100 percent Federal funding
Total	100%	32%	25%	43%
Field of research				
Physical sciences, total	100	24	28	48
Chemistry	100	35	33	33
Physics and astronomy	100	10	21	69
Engineering, total	100	43	20	37
Electrical	100	20	18	62
Mechanical	100	34	22	44
Metallurgical/materials	100	45	32	24
Chemical	100	34	22	44
Civil	100	74	18	7
Other, n.e.c.	100	68	11	20
Computer science	100	44	32	25
Materials science	100	12	32	57
Interdisciplinary, n.e.c.	100	33	28	39
Type of university[2]				
Large private (N=11)	100	19	15	66
Large public (N=27)	100	32	24	44
Smaller private (N=42)	100	19	37	43
Smaller public (N=77)	100	50	24	26

[1]Statistical estimates refer to research instrument systems (including all dedicated accessories and components) originally costing $10,000-$1,000,000 in physical science, engineering, and computer science departments and facilities at the 157 largest R&D colleges and universities in the U.S. Estimates limited to systems used for research in 1982. Sample size = 2,582 systems.

[2]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million; "N" indicates number of institutions in each size class.

NOTE: Sum of percents may not equal 100 because of rounding.

Table B-28. Percent of academic research instrument systems in use, that was acquired with 50 percent or more Federal funding, by field and type of university: National estimates, 1978-82[1]

Principal field of research use and type of university	Percent of systems with 50 percent or more Federal funding, by year of purchase				
	1982	1981	1980	1979	1978
Total, selected fields	51%	58%	58%	56%	62%
Field of research					
Chemistry	37	43	65	56	62
Physics and astronomy	88	79	89	69	90
Engineering	54	57	46	47	39
Computer science	36	55	22	34	65
Interdisciplinary, n.e.c.[2]	74	62	69	87	74
Type of university[3]					
Large private (N=11)	68	83	69	73	87
Large public (N=27)	52	57	60	61	76
Smaller private (N=42)	67	52	68	53	90
Smaller public (N=77)	33	53	60	41	28

[1]Statistical estimates refer to research instrument systems costing $10,000-$1,000,000 in 1982 equipment inventories of physical science, engineering and computer science departments and facilities at the 157 largest R&D universities in the U.S. Estimates limited to instrument systems in research use in 1982. Sample size = 1,556 instrument systems.

[2]Includes materials science.

[3]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million; "N" indicates number of institutions in each size class.

NOTE: Sum of percents may not equal 100 because of rounding.

Table B-29. Federal funding of department/facility purchases of research equipment, by field, type of university, and size of department/facility: National estimates, FY 1982 (actual) and FY 1983 (anticipated)[1]

Principal field of research in department/facility, type of university, and size of department/facility	Percent of research equipment funding from Federal sources	
	FY 1982 (actual)	FY 1983 (anticipated)
Total, selected fields	56%	54%
Field of research		
Chemistry	54	53
Physics and astronomy	77	75
Engineering	42	41
Computer science	48	50
Interdisciplinary, n.e.c.[2]	69	72
Type of university[3]		
Large private (N=11)	74	78
Large public (N=27)	56	54
Smaller private (N=42)	56	59
Smaller public (N=77)	42	34
Size of department/facility[4]		
Larger ($200,000 or more)	60	62
Medium ($50,000-$199,999)	41	35
Small (under $50,000)	32	35

[1]Statistical estimates encompass all research departments and all nondepartmental research facilities in the physical sciences, engineering and computer science at the 157 largest R&D universities in the U.S., except: (a) departments with no research instrument systems costing $10,000 or more and (b) research installations consisting of interrelated components costing over $1 million (large observatories, reactors, accelerators, etc.). Sample size = 353 departments/facilities.

[2]Includes materials science.

[3]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million; "N" indicates number of institutions in each size class.

[4]Classification based on reported FY 1982 expenditures for research equipment.

NOTE: Sum of percents may not equal 100 because of rounding.

Table B-30. Location of academic research instrument systems in use, by 1982 research status: National estimates, 1982[1]

System location	Number and percent of instrument systems, by 1982 research status					
	Total		State-of-the-art systems		Other systems	
	No.	Percent	No.	Percent	No.	Percent
Total, selected fields	17,591	100%	3,855	100%	13,735	100%
Within department lab of individual principal investigator	9,607	55	2,225	58	7,382	54
Shared-access facilities, total	7,983	45	1,629	42	6,352	46
National, regional or inter-university facility	307	2	87	2	219	2
Nondepartmental research facility	1,472	8	234	6	1,237	9
Department-managed common lab or facility	5,676	32	1,227	32	4,449	32
Other	528	3	81	2	447	3

[1]Statistical estimates refer to research instrument systems (including all dedicated accessories and components) originally costing $10,000-$1,000,000 in physical science, engineering, and computer science departments and facilities at the 157 largest R&D colleges and universities in the U.S. Estimates limited to systems used for research in 1982. Sample size = 2,582 systems.

NOTE: Sum of percents may not equal 100 because of rounding.

Table B-31. Percent of academic research instrument systems in use that are located in shared-access facilities, by field and type of university and by research status: National estimates, 1982[1]

Principal field of research use and type of university	Percent of systems in shared-access facilities,[2] by 1982 research status		
	Total	State-of-the-art systems	Other systems
Total, selected fields	45%	42%	46%
Field of research			
Physical sciences, total	34	25	36
Chemistry	37	28	39
Physics and astronomy	29	22	32
Engineering, total	48	50	48
Electrical	31	24	34
Mechanical	56	41	61
Metallurgical/materials	538	37	38
Chemical	25	26	24
Civil	53	45	56
Other, n.e.c.	71	86	64
Computer science	82	78	83
Materials science	82	75	84
Interdisciplinary, n.e.c.	44	52	42
Type of university[3]			
Large private (N=11)	41	41	41
Large public (N=27)	44	40	45
Smaller private (N=42)	47	47	47
Smaller public (N=77)	49	43	52

[1]Statistical estimates refer to research instrument systems (including all dedicated accessories and components) originally costing $10,000-$1,000,000 in physical science, engineering, and computer science departments and facilities at the 157 largest R&D colleges and universities in the U.S. Estimates limited to systems used for research in 1982. Sample size = 2,582 systems.

[2]Shared-access facilities are facilities other than within-department laboratories of principal investigators.

[3]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million; "N" indicates number of institutions in each size class.

NOTE: Sum of percents may not equal 100 because of rounding.

Table B-32. Percent of academic research instrument systems in use that are located in shared-access facilities, by field and type of university and by system purchase cost range: National estimates, 1982[1]

Principal field of research use and type of university	Percent of systems in shared-access facilities,[2] by system purchase cost range			
	Total	$10,000 - $24,999	$25,000 - $74,999	$75,000 - $1,000,000
Total, selected fields	45%	39%	46%	59%
Field of research[2]				
Physical sciences, total	34	25	39	53
Chemistry	37	27	40	66
Physics and astronomy	29	22	38	33
Engineering, total	48	46	48	59
Electrical	31	28	30	53
Mechanical	56	56	59	44
Metallurgical/materials	38	28	38	87
Chemical	25	27	20	33
Civil	53	50	55	61
Other, n.e.c.	71	69	74	72
Computer science	82	94	66	92
Materials science	82	79	87	82
Interdisciplinary, n.e.c.	44	37	48	64
Type of university[3]				
Large private (N=11)	41	34	45	60
Large public (N=27)	44	40	45	56
Smaller private (N=42)	47	45	41	65
Smaller public (N=77)	49	43	55	63

[1]Statistical estimates refer to research instrument systems (including all dedicated accessories and components) originally costing $10,000-$1,000,000 in physical science, engineering, and computer science departments and facilities at the 157 largest R&D colleges and universities in the U.S. Estimates limited to systems used for research in 1982. Sample size = 2,582 systems.

[2]Shared-access facilities are facilities other than within-department laboratories of principal investigators.

[3]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million; "N" indicates number of institutions in each size class.

NOTE: Sum of percents may not equal 100 because of rounding.

Table B-33. Percent of academic research instrument systems in use that are located in shared-access facilities, by field and type of university and by year of purchase: National estimates, 1978-82[1]

Principal field of research use and type of university	Percent of systems in shared-access facilities,[2] by year of purchase				
	1982	1981	1980	1979	1978
Total, selected fields	42%	40%	37%	39%	40%
Field of research					
Chemistry	47	52	22	38	39
Physics and astronomy	28	24	20	25	28
Engineering	42	37	39	38	42
Computer science	69	95	93	90	100
Interdisciplinary, n.e.c.[3]	69	37	50	40	46
Type of university[4]					
Large private (N=11)	42	25	43	33	43
Large public (N=27)	45	41	40	46	43
Smaller private (N=42)	41	53	41	42	52
Smaller public (N=77)	41	52	32	38	33

[1]Statistical estimates refer to research instrument systems costing $10,000-$1,000,000 in 1982 equipment inventories of physical science, engineering and computer science departments and facilities at the 157 largest R&D universities in the U.S. Estimates limited to instrument systems in research use in 1982. Sample size = 1,556 instrument systems.

[2]Shared-access facilities are facilities other than within-department laboratories of principal investigators.

[3]Includes materials science.

[4]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million; "N" indicates number of institutions in each size class.

NOTE: Sum of percents may not equal 100 because of rounding.

Table B-34. Research function of academic research instrument systems in use, by field and type of university: National estimates, 1982[1]

Principal field of research use and type of university	Percent of instrument systems by 1982 system research function			
	Total	Dedicated[2]		General purpose
		Modified	Not modified	
Total, selected fields	100%	8%	27%	65%
Field of research				
Physical sciences, total	100	8	29	63
Chemistry	100	8	22	70
Physics and astronomy	100	8	38	54
Engineering, total	100	7	28	64
Electrical	100	9	35	56
Mechanical	100	6	36	58
Metallurgical/materials	100	11	20	69
Chemical	100	18	33	49
Civil	100	2	19	79
Other, n.e.c.	100	7	18	75
Computer science	100	1	16	83
Materials science	100	6	14	80
Interdisciplinary, n.e.c.	100	9	25	66
Type of unviersity[3]				
Large private (N=11)	100	8	27	65
Large public (N=27)	100	10	26	64
Smaller private (N=42)	100	9	29	62
Smaller public (N=77)	100	6	23	71

[1]Statistical estimates refer to research instrument systems (including ...l dedicated accessories and components) originally costing $10,000-$1,000,000 in physical science, engineering, and computer science departments and facilities at the 157 largest R&D colleges and universities in the U.S. Estimates limited to systems used for research in 1982. Sample size = 2,582 systems.

[2]Dedicated for use in a specific experiment, or series of experiments, as distinguished from general purpose research instruments. Dedicated instrument systems may or may not involve modifications: "any special calibration, programming or other modification which rendered the instrument suitable for general purpose use."

[3]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million; "N" indicates number of institutions in each size class.

NOTE: Sum of percents may not equal 100 because of rounding.

Table B-35. Mean number of research users in 1982 of academic research instrument systems in use, by research status and purchase price cost and by system research function: National estimates, 1982[1]

1982 system research status and system purchase cost	Mean number of research users, by 1982 system research function			
	Total	Dedicated[2]		General purpose
		Modified	Not modified	
Total, selected fields	17.9	7.6	8.0	22.8
Research status				
State-of-the-art	15.2	6.6	10.1	18.2
Other systems in research use	18.7	7.8	7.3	24.1
Purchase cost				
$10,000-$24,999	14.5	7.5	7.1	18.3
$25,000-$74,999	18.4	7.2	7.9	23.8
$75,000-$1,000,000	30.1	8.6	15.0	36.8

[1]Statistical estimates refer to research instrument systems (including all dedicated accessories and components) originally costing $10,000-$1,000,000 in physical science, engineering, and computer science departments and facilities at the 157 largest R&D colleges and universities in the U.S. Estimates limited to systems used for research in 1982. Sample size = 2,582 systems.

[2]Dedicated for use in a specific experiment or series of experiments, as distinguished from general purpose research instruments. Dedicated instrument systems may or may not involve modifications: "any special calibration, programming or other modification which rendered the instrument unsuitable for general purpose use."

Table B-36. Mean number of research users in 1982 of academic research instrument systems in use, by field and type of university and by system research function: National estimates, 1982[1]

Principal field of research use and type of university	Mean number of research users, by 1982 system research function			
	Total	Dedicated[2]		General purpose[1]
		Modified[3]	Not modified[2]	
Total, selected fields	18.0	7.6	8.2	23.0
Field of research				
Physical sciences, total	15.2	6.9	8.4	19.3
Chemistry	17.9	6.1	10.3	21.7
Physics and astronomy	11.4	8.2	6.8	14.9
Engineering, total	14.4	6.1	6.7	18.3
Electrical	20.5	6.5	5.1	28.8
Mechanical	11.3	8.1	4.3	15.9
Metallurgical/materials	11.6	9.4	5.6	13.6
Chemical	6.5	3.2	4.0	9.2
Civil	13.4	4.5	3.8	16.1
Other, n.e.c.	16.1	5.8	16.2	17.0
Computer science	64.3	52.6	23.9	69.9
Materials science	35.8	27.0	5.5	41.2
Interdisciplinary, n.e.c.	14.1	10.0	8.7	16.7
Type of unviersity[3]				
Large private (N=11)	36.0	8.6	6.3	49.7
Large public (N=27)	16.5	8.9	10.8	20.5
Smaller private (N=42)	12.0	5.3	6.0	16.0
Smaller public (N=77)	12.8	6.3	7.8	15.1

[1]Statistical estimates refer to research instrument systems (including all dedicated accessories and components) originally costing $10,000-$1,000,000 in physical science, engineering, and computer science departments and facilities at the 157 largest R&D colleges and universities in the U.S. Estimates limited to systems used for research in 1982. Sample size = 2,582 systems.

[2]Dedicated for use in a specific experiment or series of experiments, as distinguished from general purpose research instruments. Dedicated instrument systems may or may not involve modifications: "any special calibration, programming or other modification which rendered the instrument unsuitable for general purpose use."

[3]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million: "N" indicates number of institutions in each size class.

Table B-37. Mean number of research users in 1982 of academic research instrument systems in use, by field and type of university and by 1982 research status: National estimates, 1982[1]

Principal field of research use and type of university	Mean number of research users, by 1982 system research status		
	Total	State-of-the-art systems	Other systems
Total, selected fields	17.9	15.2	18.7
Field of research			
Physical sciences, total	15.2	13.2	15.7
Chemistry	17.9	15.3	18.5
Physics and astronomy	11.4	10.9	11.5
Engineering, total	14.4	14.7	14.3
Electrical	20.5	19.6	20.8
Mechanical	11.3	8.2	12.5
Metallurgical/materials	16.6	11.0	11.8
Chemical	6.5	7.4	6.3
Civil	13.4	14.5	13.1
Other, n.e.c.	16.1	18.1	15.2
Computer science	64.3	32.4	74.3
Materials science	35.8	21.4	39.1
Interdisciplinary, n.e.c.	14.1	15.4	13.7
Type of unviersity[2]			
Large private (N=11)	36.0	23.2	40.0
Large public (N=27)	16.5	17.5	16.3
Smaller private (N=42)	12.0	12.5	11.8
Smaller public (N=77)	12.8	10.9	13.4

[1]Statistical estimates refer to research instrument systems (including all dedicated accessories and components) originally costing $10,000-$1,000,000 in physical science, engineering, and computer science departments and facilities at the 157 largest R&D colleges and universities in the U.S. Estimates limited to systems used for research in 1982. Sample size = 2,582 systems.

[2]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or or more; "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million; "N" indicates number of institutions in each size class U.S.

Table B-38. Mean number of research users in 1982 of academic research instrument systems in use, by field and type of university and by system purchase price range: National estimates, 1982[1]

Principal field of research use and type of university	Mean number of research users, by system purchase price range			
	Total	$10,000-$24,999	$25,000-$74,999	$75,000-$1,000,000
Total, selected fields	17.9	14.5	18.4	30.1
Field of research				
Physical sciences, total	15.2	10.8	16.0	28.4
Chemistry	17.9	11.1	20.9	36.3
Physics and astronomy	11.4	10.4	10.5	16.6
Engineering, total	14.4	13.4	13.6	22.6
Electrical	20.5	20.4	18.0	28.1
Mechanical	11.3	12.6	8.0	14.3
Metallurgical/materials	11.6	8.6	11.0	27.0
Chemical	6.5	5.8	5.8	16.4
Civil	13.4	11.8	15.2	16.9
Other, n.e.c.	16.1	13.5	18.7	24.8
Computer science	64.3	61.8	55.5	96.0
Materials science	35.8	26.4	52.9	29.3
Interdisciplinary, n.e.c.	14.1	11.9	12.7	25.9
Type of university[2]				
Large private (N=11)	36.0	29.8	39.2	58.1
Large public (N=27)	16.5	12.3	16.1	31.1
Smaller private (N=42)	12.0	9.2	12.3	20.3
Smaller public (N=77)	12.8	11.3	13.4	18.9

[1]Statistical estimates refer to research instrument systems (including all dedicated accessories and components) originally costing $10,000-$1,000,000 in physical science, engineering, and computer science departments and facilities at the 157 largest R&D colleges and universities in the U.S. Estimates limited to systems used for research in 1982. Sample size = 2,582 systems.

[2]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or or more; "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million; "N" indicates number of institutions in each size class.

Table B-39. Mean number of research users in 1982 of academic research instrument systems in use, by field and type of university and by system age: National estimates, 1982[1]

Principal field of research use and type of university	Mean number of research users, by system age (from year of purchase)			
	Total	1-5 years (1978-82)	6-10 years (1973-77)	11+ years (before 1973)
Total, selected fields	18.0	21.5	15.4	11.8
Field of research				
Physical sciences, total	15.1	16.1	17.5	11.3
Chemistry	18.0	18.7	21.2	13.0
Physics and astronomy	11.2	12.0	11.2	9.9
Engineering, total	14.8	18.1	11.1	8.9
Electrical	21.3	23.8	13.7	14.0
Mechanical	11.4	15.4	8.6	5.1
Metallurgical/materials	21.1	11.0	12.6	15.5
Chemical	6.5	7.1	4.1	7.8
Civil	13.1	13.5	20.8	8.6
Other, n.e.c.	16.3	25.5	11.2	8.2
Computer science	67.3	64.6	71.4	*
Materials science	35.8	63.2	20.8	19.6
Interdisciplinary, n.e.c.	14.5	15.6	10.6	20.0
Type of university[2]				
Large private (N=11)	36.1	39.9	24.6	31.2
Large public (N=27)	16.5	19.1	15.0	11.2
Smaller private (N=42)	12.0	15.3	7.6	8.3
Smaller public (N=77)	12.8	13.9	14.9	9.1

[1]Statistical estimates refer to research instrument systems (including all dedicated accessories and components) originally costing $10,000-$1,000,000 in physical science, engineering, and computer science departments and facilities at the 157 largest R&D colleges and universities in the U.S. Estimates limited to systems used for research in 1982. Sample size = 2,582 systems.

[2]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million; "N" indicates number of institutions in each size class.

*Insufficient sample.

Table B-40. Mean number of research users in 1982 of academic research instrument systems in use, by field and type of university and by system condition: National estimates, 1982[1]

Principal field of research use and type of university	Mean number of research users, by system condition			
	Total	Excellent	Average	Poor
Total, selected fields	18.0	19.1	17.1	16.5
Field of research				
Physical sciences, total	15.1	16.4	14.1	12.8
Chemistry	18.0	19.7	17.5	14.0
Physics and astronomy	11.2	12.3	9.6	10.7
Engineering, total	14.8	18.5	11.4	7.3
Electrical	21.3	25.2	18.3	9.9
Mechanical	11.4	14.7	8.1	3.0
Metallurgical/materials	12.1	10.7	13.3	16.5
Chemical	6.5	7.1	6.8	3.9
Civil	13.1	18.5	10.6	4.2
Other, n.e.c.	16.3	23.1	9.7	4.7
Computer science	67.3	29.2	104.2	173.3
Materials science	35.0	67.0	12.1	14.2
Interdisciplinary, n.e.c.	14.5	17.6	12.7	9.1
Type of university[2]				
Large private (N=11)	36.0	33.9	36.1	47.0
Large public (N=27)	16.5	18.9	14.3	13.2
Smaller private (N=42)	12.0	15.4	8.2	7.1
Smaller public (N=77)	12.8	12.2	14.4	8.6

[1]Statistical estimates refer to research instrument systems (including all dedicated accessories and components) originally costing $10,000-$1,000,000 in physical science, engineering, and computer science departments and facilities at the 157 largest R&D colleges and universities in the U.S. Estimates limited to systems used for research in 1982. Sample size = 2,582 systems.

[2]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million; "N" indicates number of institutions in each size class.

Table B-41. Mean number of research users in 1982 of academic research instrument systems in use, by field and type of university and by system location: National estimates, 1982[1]

Principal field of research use and type of university	Mean number of research users, by system location		
	Total	Within-department lab of P.I.	Shared-access facility
Total, selected fields	18.0	8.9	28.9
Field of research			
Physical sciences, total	15.1	7.7	28.5
Chemistry	18.0	8.0	34.3
Physics and astronomy	11.2	7.2	19.4
Engineering, total	14.8	10.2	19.3
Electrical	21.3	18.5	26.8
Mechanical	11.4	6.7	14.8
Metallurgical/materials	12.1	6.7	18.9
Chemical	6.5	5.2	10.4
Civil	13.1	5.7	19.8
Other, n.e.c.	16.3	6.5	20.3
Computer science	67.3	19.4	77.7
Materials science	35.8	9.3	41.8
Interdisciplinary, n.e.c.	14.5	9.7	20.1
Type of university[2]			
Large private (N=11)	36.0	14.8	67.9
Large public (N=27)	16.5	8.2	27.1
Smaller private (N=42)	12.0	7.0	17.2
Smaller public (N=77)	12.8	6.7	19.0

[1]Statistical estimates refer to research instrument systems (including all dedicated accessories and components) originally costing $10,000-$1,000,000 in physical science, engineering, and computer science departments and facilities at the 157 largest R&D colleges and universities in the U.S. Estimates limited to systems used for research in 1982. Sample size = 2,582 systems.

[2]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million; "N" indicates number of institutions in each size class.

Table B-42. Types of research users of academic research instrument systems in use, by system purchase cost range and research status: National estimates, 1982[1]

System purchase cost range and 1982 system research status	Percent of systems used in 1982 by:[2]				
	Faculty this dept./facility	Graduate students and post doctorates this dept./facility	Researchers from other departments of this university[3]	Researchers from other universities[3]	Nonacademic researchers
Total, selected fields	87%	84%	30%	13%	9%
Purchase cost					
$10,000-$24,999	85	83	26	9	6
$25,000-$74,999	89	84	31	13	11
$75,000-$1,000,000	94	88	44	28	20
1982 research status					
State-of-the-art systems	91	82	25	16	13
Other systems	86	84	32	12	8

[1]Statistical estimates refer to research instrument systems (including all dedicated accessories and components) originally costing $10,000-$1,000,000 in physical science, engineering, and computer science departments and facilities at the 157 largest R&D colleges and universities in the U.S. Estimates limited to systems used for research in 1982. Sample size = 2,582 systems.

[2]Entries indicate percent of active research instrument systems used for research in 1982 by at least one person in the category specified.

[3]Entries include faculty, post-doctorate, and graduate student users.

NOTE: Sum of percents may not equal 100 because of rounding.

Table B-43. Types of research users of academic research instrument systems in use, by field and type of university: National estimates, 1982[1]

Principal field of research use and type of university	Percent of systems used in 1982 by:[2]				
	Faculty this dept./facility	Graduate students and post doctorates this dept./facility	Researchers from other departments of this university[3]	Researchers from other universities[3]	Nonacademic researchers
Total, selected fields	87	84	30	13	9
Field of research					
Physical sciences, total	87	89	27	17	8
Chemistry	86	92	29	19	9
Physics and astronomy	88	86	24	15	6
Engineering, total	90	79	27	7	11
Electrical	88	89	39	15	7
Mechanical	95	93	22	3	6
Metallurgical/materials	90	80	28	8	6
Chemical	80	78	26	5	2
Civil	84	88	24	1	5
Other, n.e.c.	92	56	21	6	28
Computer science	96	88	62	11	8
Materials science	64	66	56	6	0
Interdisciplinary, n.e.c.	81	81	41	21	10
Type of university[4]					
Large private (N=11)	83	88	32	18	[illegible]
Large public (N=27)	86	88	22	13	10
Smaller private (N=42)	89	84	20	15	8
Smaller public (N=77)	92	78	24	13	12

[1]Statistical estimates refer to research systems (including all dedicated accessories and components) originally costing $10,000,000 in physical science, engineering, and computer science departments and facilities at the 157 largest R&D colleges and universities in the U.S. Estimates limited to systems used for research in 1982. Sample size = 2,582 systems.

[2]Entries indicate percent of active research instrument systems used for research in 1982 by at least one person in the category specified.

[3]Entries include faculty, post-doctorate, and graduate student users.

[4]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more, "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million; "N" indicates number of institutions in each size class.

NOTE: Sum of percents may not equal 100 because of rounding.

Table B-44. Department/facility assessment of available instrumentation support services, by field, type of university, and size of department/facility: National estimates, 1982[1]

Principal field of research in department/facility, type of university, and size of department/facility	Percent of departments/facilities assessing instrumentation support services as:[2]				
	Total	Excellent	Adequate	Insufficient	Nonexistent
Total, selected fields	100%	6%	47%	40%	6%
Field of research					
Physical sciences, total	100	11	42	41	6
Chemistry	100	3	32	53	12
Physics and astronomy	100	18	52	29	1
Engineering, total	100	3	50	41	6
Electrical	100	4	43	50	3
Mechanical	100	5	70	25	0
Metallurgical/materials	100	6	37	54	4
Chemical	100	2	58	40	0
Civil	100	0	54	42	4
Other, n.e.c.	100	4	39	44	14
Computer science	100	4	36	42	18
Interdisciplinary, n.e.c.[3]	100	15	66	20	0
Type of University[4]					
Large private (N=11)	100	14	39	44	2
Large public (N=27)	100	10	51	31	6
Smaller private (N=42)	100	4	37	47	12
Smaller public (N=77)	100	4	51	40	5
Size of department/facility[5]					
Large ($200,000 or more)	100	9	39	50	2
Medium ($50,000 - $199,999)	100	4	42	48	5
Small (under $50,0000)	100	7	60	23	11

[1]Statistical estimates encompass all research departments and all nondepartmental research facilities in the physical sciences, engineering and computer science at the 157 largest R&D universities in the U.S., except: (a) departments with no research instrument systems costing $10,000 or more and (b) research installations consisting of interrelated components costing over $1 million (large observatories, reactors, accelerators, etc.). Sample size = 353 departments/facilities.

[2]Item refers to "the instrumentation support services (e.g., machine shop, electronics shop) at this department or facility."

[3]Includes materials science.

[4]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million; "N" indicates number of institutions in each size class.

[5]Classification is based on FY 1982 expenditures for research equipment.

NOTE: Sum of percents may not equal 100 because of rounding.

Table B-45. Mean FY 1982 expenditures for maintenance and repair of research equipment per department/facility, by field, type of university, size of department/facility, and assessed adequacy of instrumentation and by types of expenditure: National estimates, FY 1982[1]

[Dollars in thousands]

Principal field of research in department/facility, type of university, size of department/facility, and adequacy of instrumentation M/R facilities	Per department mean FY 1982 expenditures for maintenance and repair (M/R) of research equipment			
	Total	M/R service contracts and field service	University-employed M/R personnel salaries	M/R supplies, equipment, and facilities
Total, selected fields	$ 49.9	$14.4	$25.7	$ 9.7
Field of research				
Chemistry	60.8	12.0	35.9	13.0
Physics and astronomy	91.4	18.6	53.9	18.9
Engineering	29.8	9.3	15.3	5.2
Computer science	72.2	39.2	17.8	15.3
Interdisciplinary, n.e.c.	64.2	23.9	29.5	10.9
Type of university[2]				
Large private (N=11)	124.7	46.6	55.7	22.4
Large public (N=27)	64.6	14.2	38.2	12.2
Smaller private (N=42)	43.9	19.1	16.7	8.1
Smaller public (N=77)	32.0	7.0	18.0	7.0
Size of department/facility[3]				
Large ($200,000 or more)	96.6	29.5	49.7	17.4
Medium ($50,000-199,999)	41.1	9.8	21.6	9.7
Smaller (under $50,000)	11.6	4.0	5.7	1.9
Adequacy of M/R facilities[4]				
Excellent	88.4	23.7	42.1	22.5
Adequate	46.1	13.0	23.8	9.2
Insufficient	53.9	15.0	29.1	9.8
Nonexistant	15.4	12.0	2.2	1.2

[1]Statistical estimates encompass all research departments and all nondepartmental research facilities in the physical sciences, engineering and computer science at the 157 largest R&D universities in the U.S., except: (a) departments with no research instrument systems costing $10,000 or more and (b) research installations consisting of interrelated components costing over $1 million (large observatories, reactors, accelerators, etc.). Sample size = 353 departments/facilities.

[2]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million; "N" indicates number of institutions in each size class.

[3]Classification is based on FY 1982 expenditures for research equipment.

[4]Department/facility head's assessment of the adequacy of "the instrumentation support services (e.g., machine shop, electronics shop) at this department or facility."

Table B-46. Principal means of servicing academic research instrument systems in use, by field, type of university, and age of system: National estimates, 1982[1]

Principal field of research use, type of university, and age of system	Percent of in-use systems, by principal means of servicing[2]					
	Total	Service contract	None required	Field service	Univ. M/R personnel	Research personnel
Total, selected fields	100%	12%	18%	24%	25%	21%
Field of research						
Physical services, total	100	7	18	25	27	22
Chemistry	100	8	15	29	30	17
Physics and astronomy	100	7	22	18	24	29
Engineering, total	100	12	20	21	26	21
Electrical	100	14	14	18	26	28
Mechanical	100	10	35	22	25	8
Metallurgical/materials	100	13	21	27	20	19
Chemical	100	9	19	28	15	29
Civil	100	22	23	29	23	3
Other, n.e.c.	100	11	13	14	34	27
Computer science	100	49	8	28	13	2
Materials science	100	21	12	20	20	28
Interdisciplinary, n.e.c.	100	17	20	24	21	18
Type of university[3]						
Large private (N=11)	100	19	23	24	16	17
Large public (N=27)	100	10	21	21	27	20
Smaller private (N=42)	100	12	17	28	25	18
Smaller public (N=77)	100	12	13	20	29	26
Age of instrument system[4]						
1-5 years (1978-82)	100	17	21	26	19	17
6-10 years (1973-77)	100	7	15	23	27	28
11 or more years (before 1973)	100	5	16	17	40	22

[1]Statistical estimates refer to research instrument systems (including all dedicated accessories and components) originally costing $10,000-$1,000,000 in physical science, engineering, and computer science departments and facilities at the 157 largest R&D colleges and universities in the U.S. Estimates limited to systems used for research in 1982. Sample size = 2,582 systems.

[2]If more than one form of servicing was used in 1982, the instrument system was assigned to the first-listed category that applies.

[3]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million; "N" indicates number of institutions in each size class.

[4]Classification is based on original year of purchase.

NOTE: Sum of percents may not equal 100 because of rounding.

Table B-47. Percent of academic research instrument systems in use that are in excellent working condition, by means of servicing and by age: National estimates, 1982[1]

Means of servicing system in 1982[2]	Percent of in-use systems in excellent working condition,[3] by age group (from year of purchase)				
	Total	1-5 years (1978-82)	6-10 years (1973-77)	11-15 years (1968-72)	16+ years (Before 1968)
Total, selected fields	51%	67%	37%	27%	22%
No service required	69	82	66	36	30
Service contract	65	71	52	31	4
Field services, as needed	45	59	25	17	13
University-employed maintenance/repair staff	46	66	28	29	27
Research personnel (faculty, post-docs, graduate students)	42	60	33	24	10

[1]Statistical estimates refer to research instrument systems (including all dedicated accessories and components) originally costing $10,000-$1,000,000 in physical science, engineering, and computer science departments and facilities at the 157 largest R&D colleges and universities in the U.S. Estimates limited to systems used for research in 1982. Sample size = 2,582 systems.

[2]For a given instrument system, more than one category may apply.

[3]Based on user characterization.

NOTE: Sum of percents may not equal 100 because of rounding.

Table B-48. Mean annual expenditures per system for maintenance and repair of academic research instrument systems in use, by field, type of university, principal means of servicing, and purchase cost and by age: National estimates, 1982[1]

Principal field of research use, type of university, principal means of servicing and purchase cost	Per system mean expenditures in 1982 for maintenance and repair by system age group (from year of purchase)			
	Total	1-5 years (1978-82)	6-10 years (1973-77)	11+ years (before 1973)
Total, selected fields	$1,700	$1,900	$1,700	$1,400
Field of research				
Chemistry	1,600	1,600	1,600	1,700
Physics and astronomy	2,100	2,400	2,700	1,400
Engineering	1,300	1,400	1,000	1,200
Computer science	3,700	3,600	5,300	*
Interdisiplinary, n.e.c.	2,400	2,600	2,600	1,800
Type of university[2]				
Large private (N=11)	2,200	2,400	2,000	1,600
Large public (N=27)	1,900	1,800	2,000	1,700
Smaller private (N=42)	1,900	2,200	1,800	1,300
Smaller public (N=77)	1,200	1,300	1,300	1,100
Principal means of servicing[3]				
Service contract	5,700	5,700	6,300	5,400
No service required	0	0	0	0
Field service, as needed	2,200	1,900	2,100	2,300
University-employed maintenance/repair staff	1,600	1,300	2,200	1,500
Research personnel (faculty, post-docs, graduate students)	1,000	1,200	800	800
Purchase cost				
$10,000-$24,999	500	500	600	500
$25,000-74,999	1,600	1,600	1,400	1,700
$75,000-$1,000,000	7,200	7,800	7,400	5,200

[1]Statistical estimates refer to research instrument systems (including all dedicated accessories and components) originally costing $10,000-$1,000,000 in physical science, engineering, and computer science departments and facilities at the 157 largest R&D colleges and universities in the U.S. Estimates limited to systems used for research in 1982. Sample size = 2,582 systems.

[2]"Large" refers to FY 1980 separately budgeted R&D expenditures of $33 million or more; "smaller" refers to FY 1980 R&D expenditures of $28-32.9 million; "N" indicates number of institutions in each size class.

[3]If more than one means of servicing applied in 1982, the instrument system was assigned to the category listed first. Consequently, dollar estimates for late-listed categories may understate actual expenditures.

*Insufficient sample.

APPENDIX C

Phase I Advisory Group

APPENDIX C

Phase I Advisory Group

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APPENDIX D

Interagency Working Group on University Research Instrumentation

APPENDIX D

Interagency Working Group on University Research Instrumentation

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APPENDIX E

Department/Facility Questionnaire

Form Number

OMB No. 3145-0067
Expiration Date 9/30/85

NATIONAL SCIENCE FOUNDATION

DIVISION OF SCIENCE RESOURCES STUDIES

NATIONAL SURVEY OF ACADEMIC RESEARCH INSTRUMENTS AND INSTRUMENTATION NEEDS

DEPARTMENT/FACILITY QUESTIONNAIRE

THIS REPORT IS AUTHORIZED BY LAW (P.L. 96-44). WHILE YOU ARE NOT REQUIRED TO RESPOND, YOUR COOPERATION IS NEEDED TO MAKE THE RESULTS OF THIS SURVEY COMPREHENSIVE, ACCURATE, AND TIMELY. INFORMATION GATHERED IN THIS SURVEY WILL BE USED ONLY FOR DEVELOPING STATISTICAL SUMMARIES. INDIVIDUAL PERSONS, INSTITUTIONS, AND DEPARTMENTS WILL NOT BE IDENTIFIED IN PUBLISHED SUMMARIES OF THE DATA.

BACKGROUND AND INSTRUCTIONS

In recent years, widespread concern has developed about whether university research scientists and engineers have sufficient access to the kinds of equipment needed to permit continuing research at the frontier of scientific knowledge. To assist the National Science Foundation and other Federal agencies in setting appropriate equipment funding levels and priorities, this Congressionally mandated survey is intended to document, for the first time: (a) the amount, cost, and condition of the scientific research equipment currently available in the nation's principal research universities, and (b) the nature and extent of the need for upgraded or expanded equipment in the major fields of science and engineering.

The survey is being conducted in two phases. The current phase deals with research equipment in the physical sciences and engineering/computer science. Next year, in Phase II, the emphasis will be on the biological, environmental, and agricultural sciences.

This Department (or nondepartmental research facility) Questionnaire seeks a broad overview of equipment-related expenditures and needs in this department (or facility). Items 1-10 (Parts A and B) are factual in nature and may be delegated to any person or persons who can provide the requested data. In these sections, informed estimates are acceptable whenever precise information is not available from annual reports or other data sources. Items 11-16 (Part C) call for judgmental assessments about equipment-related research needs and priorities of the department (or facility) as a whole and should be answered by the department chairperson (or facility director) or by a designee who is in a position to make such judgments. We urge that particular attention be given to item 16, which asks for this department's (or facility's) recommendations about needed changes in equipment funding policies and procedures.

This form should be returned by May 30, 1983. Your cooperation in returning the survey form promptly is very important. Please direct any questions about this form either to your university study coordinator or to Ms. Dianne Walsh at Westat, Inc., the NSF contractor for this study (301-251-1500).

PART A. DESCRIPTIVE INFORMATION

1. Institution name: _____

2. Department (or nondepartmental research facility) name:

   _____

3. This is a: (CHECK ONE)

   |__| 1. Department (CONTINUE WITH ITEM 4)

   |__| 2. Nondepartmental research facility (SKIP TO ITEM 6)

4. Number of doctoral degrees awarded in 1981-82 academic year to students in this department:

   _____

5. Number of members of this department who participate in ongoing research projects (do not include graduate students or postdoctorates):

   _____ Total number of persons (full-time and part-time)

   _____ FTE* number of persons

PART B. RESEARCH-RELATED FUNDING AND EXPENDITURES

6. Department (or facility) FY 1982 and anticipated FY 1983 expenditures for scientific research equipment. [SCIENTIFIC RESEARCH EQUIPMENT IS ANY ITEM (OR INTERRELATED COLLECTION OF ITEMS COMPRISING A SYSTEM) OF NONEXPENDABLE TANGIBLE PROPERTY OR SOFTWARE HAVING A USEFUL LIFE OF MORE THAN TWO YEARS AND AN ACQUISITION COST OF $500 OR MORE WHICH IS USED WHOLLY OR IN PART FOR RESEARCH. INCLUDE ALL SCIENTIFIC RESEARCH EQUIPMENT ACQUIRED IN THIS DEPARTMENT (OR FACILITY) IN FY 1982, FROM ALL SOURCES -- FEDERAL, STATE, INSTITUTIONAL, INDUSTRIAL, ETC.]

   $_____ FY 1982 expenditures for scientific research equipment

   $_____ Anticipated FY 1983 expenditures for scientific research equipment

*In computing number of FTEs (full-time equivalents), persons employed in this department on less than a full-time basis should be counted to reflect their decimal fraction of full-time equivalency. Example: if a department employs 25 pertinent faculty members, 20 full-time and 5 with half-time appointments, the FTE number is 20 + (5 x .5) = 22.5.

7. Please provide an approximate breakdown by source of funds for this department's (or facility's) FY 1982 expenditures and estimated FY 1983 expenditures for scientific research equipment. [NOTE: ENTRIES IN EACH COLUMN SHOULD SUM TO 100 PERCENT; ESTIMATES ARE ACCEPTABLE.]

Source of funds	Percent of expenditures for scientific research equipment	
	FY 1982	FY 1983 (anticipated)
a. Federal government	_____ %	_____ %
b. Internal university funds	_____ %	_____ %
c. State equipment or capital development appropriations	_____ %	_____ %
d. Private nonprofit foundations/ organizations	_____ %	_____ %
e. Business or industry	_____ %	_____ %
f. Other (SPECIFY) _____		
_____	_____ %	_____ %
TOTAL, ALL FUNDING SOURCES	100 %	100 %

8. FY 1982 expenditures for purchase of research-related computer services at:

$_____ On-campus computing facilities

$_____ Off-campus computing facilities

9. FY 1982 expenditures for maintenance and repair of all scientific research equipment in this department (or facility):

$_____ Service contracts or field service for maintenance and repair of individual instruments

$_____ Salaries of university maintenance/repair personnel (prorate if personnel do not work full-time in this department/ facility or on servicing of research equipment)

$_____ Other direct costs of supplies, equipment and facilities for servicing of research instruments in this department/ facility

$_____ Total

10. Are the instrumentation support services (e.g., machine shop, electronics shops) at this department or facility: (CHECK ONE)

|__| 1. Excellent

|__| 2. Adequate

|__| 3. Insufficient

|__| 4. Nonexistant

PART C. ADEQUACY OF AND NEED FOR SCIENTIFIC RESEARCH EQUIPMENT

11. In terms of its capability to enable investigators to pursue their major research interests, is the research equipment in this department (or facility) generally: (CHECK ONE IN EACH COLUMN)

	Type of investigator	
	Tenured faculty (and equivalent P.I.'s)	Untenured faculty (and equivalent P.I.'s)
1. Excellent	1. |__|	1. |__|
2. Adequate	2. |__|	2. |__|
3. Insufficient	3. |__|	3. |__|

12. Are there any important subject areas (e.g., recombitant DNA, microcircuitry, plasma physics) in which investigators in this department/facility are unable to perform critical experiments in their areas of research interest due to lack of needed equipment?

\|__\| 1. Yes ⟶ 12a. What are the top priority subject areas for expansion/upgrading of presently available equipment? (SPECIFY UP TO THREE AREAS)

_____

_____

\|__\| 2. No _____

13. Assuming future total Federal research support to your department/facility remains roughly constant at present levels, how - if at all - would your department (or facility) redistribute its research funds. FOR EACH AREA, PLEASE INDICATE WHETHER FUNDING SHOULD BE PROPORTIONATELY INCREASED, DECREASED, OR MAINTAINED AT ABOUT THE PRESENT LEVEL. (NOTE: PROPORTIONATE INCREASES IN ONE OR MORE AREAS MUST BE ACCOMPANIED BY CORRESPONDING DECREASES IN OTHER AREAS. IF THE CURRENT BALANCE SHOULD BE MAINTAINED, CHECK "NO CHANGE" COLUMN FOR ALL AREAS.)

Area of Federal support	Recommended redistribution of research funds		
	1. Increase	2. Decrease	3. No change
a. Faculty salaries	|__|	|__|	|__|
b. Postdoctorate salaries	|__|	|__|	|__|
c. Graduate student support	|__|	|__|	|__|
d. Non-professional salaries	|__|	|__|	|__|
e. Equipping of startup labs	|__|	|__|	|__|
f. Equipment purchases (other than e, above)	|__|	|__|	|__|
g. Equipment maintenance	|__|	|__|	|__|
h. Other (SPECIFY) _____			
_____	|__|	|__|	|__|

14. If greater Federal funding of research equipment were possible, in which area would increased investment be most beneficial to investigators in this department/facility? (CHECK ONE)

|__| 1. Large scale regional and national facilities (large telescopes, reactors, oceanographic vessels, high performance computers, etc.)

|__| 2. Major shared access instrument systems ($50,000-$1,000,000) not presently available to department/facility members

|__| 3. Upgrading/expansion of equipment in $10,000-$50,000 range

|__| 4. General enhancement of equipment and supplies in labs of individual P.I.'s (items generally below $10,000)

|__| 5. Other (SPECIFY) _____

_____

15. In the $10,000-$1,000,000 cost range, what three items of research equipment (if any) are most needed at this time in this department/facility?

Item description	Approximate cost
_____	_____
_____	_____
_____	_____

16. How could current Federal equipment funding policies and/or procedures be modified to better meet the research needs of researchers in this department/facility?

_____

_____

_____

_____

17. Please note in the space below: (a) any additional information needed to describe the research equipment and equipment-related needs in this department/facility, or (b) any suggestions to improve this survey questionnaire.

_____

_____

_____

_____

_____

18. Person who prepared this submission:

_____ _____

NAME AND TITLE AREA CODE - EXCH - NO. - EXT.

19. How many person-hours were required to complete this form? _____ _____

HOURS MINUTES

APPENDIX F
INSTRUMENT DATA SHEET

Form Number

OMB No. 3145-0067
Expiration Date 9/30/85

NATIONAL SURVEY OF ACADEMIC RESEARCH INSTRUMENTS AND INSTRUMENTATION NEEDS

NATIONAL SCIENCE FOUNDATION
Washington, D.C. 20550

INSTRUMENT DATA SHEET

This data sheet is part of a major national assessment of the condition of university research instrumentation. The data sheet concerns a particular instrument selected (from university central records) as part of a small national sample of research instruments in your field.

The item described below (in ID BOX) is believed to be an active research instrument located in this department or research facility as of December 31, 1982. Please note in the comments section (Question 17) if this assumption is incorrect; however, please complete as much of this form as possible.

We ask that the requested factual information (items 1-8) and functional assessment data (items 9-16) be obtained from the person or persons who are most knowledgeable about the history and current status of this instrument.

All cost data should be rounded to the nearest thousand dollars. For example, a purchase cost of $25,342 should be reported as $25,000. Where exact cost (or other) data are not available, estimates are acceptable. Your estimates will be better than ours.

This study is authorized by law (P.L. 96-44). While you are not required to respond, your cooperation is needed to make the results of this survey comprehensive, accurate, and timely. Information gathered in this survey will be used only for developing statistical summaries. Individual persons, institutions, and departments will not be identified in published summaries of the data.

This form should be returned by May 30, 1983. Your cooperation in returning the survey form promptly is very important. Please direct any questions about this form either to your university study coordinator or to Ms. Dianne Walsh at Westat, Inc., the NSF contractor for this study (301-251-1500).

DEFINITION OF KEY TERMS

INSTRUMENT PURCHASE COST (initial value)

The original cost of the instrument (or its components, if built locally) at time of purchase from the manufacturer. Do not include cost of separately purchased accessories; do not subtract any discount (e.g., for trade-in) which may have been received. Please estimate if original records are not available.

ACQUISITION COST

The actual cost of this instrument when acquired at this university. If purchased new by this university, acquisition cost = purchase cost, less discount from manufacturer, if applicable. If built at this university, acquisition cost = cost of parts + estimated cost of labor. If purchased used, acquisition cost = price paid to seller. If donated or loaned (e.g., by industry) or obtained at no cost from government surplus, acquisition cost = $0.

REPLACEMENT COST

The estimated cost to purchase this instrument (or its components, if built locally) or one of roughly equivalent function and capability, at today's prices.

DEDICATED ACCESSORIES

Separately acquired "add-ons" to or components of the instrumentation system of which the instrument described below is the principal element. This includes accessories that are presently (as of December 31, 1982) dedicated solely for use with the reference instrument but are not included in its purchase cost (in item G, below). Examples: specimen preparation and photographic accessories for a particular electron microscope; oscilloscope, microprocessor, HPLC, or data system accessories for a particular spectrometer; key entry, disc drive, printer or plotter accessories for a particular microcomputer.

SYSTEM PURCHASE COST

The instrument purchase cost plus the aggregate purchase cost of its dedicated accessories, if any.

YEAR OF PURCHASE

The calendar year when this instrument (or its principal components) was originally purchased from the manufacturer.

ID BOX - INSTRUMENT IDENTIFYING DATA

A. University _____

B. Department or Facility _____

C. Instrument Description _____

_____

D. Central Records ID # _____

E. Assigned to: _____

F. Year of Purchase: 19_____ G. Instrument Purchase Cost: _____

SEE PAGE 1 FOR DEFINITION OF ALL BOLDFACE TERMS

1. Please review the identifying data (from your university's central records) in the page 1 ID BOX and make any needed corrections or additions, with special attention to items F (**YEAR OF PURCHASE**) and G (**INSTRUMENT PURCHASE COST**).

2. Where was this instrument located during 1982 when in use? (CHECK ONE)

   |__| 1 Not used for teaching or for research in 1982 (SKIP TO ITEM 17)

   |__| 2 Lab used almost exclusively for undergraduate instruction (SKIP TO ITEM 17)

   |__| 3 National, regional, or interuniversity instrumentation lab (CONTINUE TO ITEM 3)

   |__| 4 Nondepartmental research facility (CONTINUE TO ITEM 3)

   |__| 5 Department-managed common lab or instrumentation facility (CONTINUE TO ITEM 3)

   |__| 6 Within-department lab of principal investigator (CONTINUE TO ITEM 3)

   |__| 7 Other (SPECIFY) _____

3. Does this instrument have any **DEDICATED ACCESSORIES** not included in the **INSTRUMENT PURCHASE COST** (from ID BOX, item G)?

   |__| 1 Yes ⟶ 3a. Please describe, and estimate purchase cost for this instrument's separately purchased **DEDICATED ACCESSORIES.**

   |__| 2 No

Description of major accessories	Purchase cost
_____	$_____
_____	$_____
_____	$_____
_____	$_____
Estimated aggregate purchase cost of all **DEDICATED ACCESSORIES** not included in ID BOX item G (those described plus all others)	$_____
SYSTEM PURCHASE COST for instrument plus all **DEDICATED ACCESSORIES**	$_____

4. Year instrument acquired at this university:

   19 _____

5. **ACQUISITION COST** for this instrument and its accessories:

   $_____ Instrument acquisition cost

   $_____ Accessory acquisition cost

   $_____ Total

6. Estimated **REPLACEMENT COST** for this instrument and its accessories:

   $_____ Instrument replacement cost

   $_____ Accessory replacement cost

   $_____ Total

7. How was this instrument acquired at this university? (CHECK ONE)

|_| 1 Purchased new

|_| 2 Purchased used

|_| 3 Locally built (at or for this university)

|_| 4 Transferred from another university, e.g., by incoming faculty member (SKIP TO ITEM 9)

|_| 5 Government surplus (SKIP TO ITEM 9)

|_| 6 Donated new (SKIP TO ITEM 9)

|_| 7 Donated used (SKIP TO ITEM 9)

|_| 8 Other (SPECIFY) _____

_____

8. Source(s) of funds for acquisition of this instrument (and accessories) at this university. (SPECIFY APPROXIMATE PERCENTAGE CONTRIBUTION TO TOTAL ACQUISITION COST FOR EACH APPLICABLE SOURCE.)

Funding contribution (percent)	Funding source
	Federal sources:
_____	NSF (National Science Foundation)
_____	NIH (National Institutes of Health)
_____	DOD (Department of Defense)
_____	DOE (Department of Energy)
_____	Other Federal sources (SPECIFY): _____
	Non-Federal sources:
_____	University or department funds
_____	State grant or appropriation
_____	Private nonprofit foundation
_____	Business or industry
_____	Other (SPECIFY) _____
100%	Total

9. How much was spent for maintenance and repair (not for operation) of this instrument and its accessories in 1982?

$_____

10. Means of servicing (maintenance/repair) this instrument during 1982: (CHECK ALL THAT APPLY)

|_| 1 None required

|_| 2 Service contract

|_| 3 Field service, as needed

|_| 4 University-employed maintenance/repair staff

|_| 5 Research personnel (faculty, post-docs, graduate students)

|_| 6 Other (SPECIFY) _____

11. Instrument's general working condition during 1982: (CHECK ONE)

|_| 1 Excellent

|_| 2 Average

|_| 3 Poor (e.g., unreliable, frequent breakdowns, difficult to maintain or service)

|_| 4 Inoperable entire year

12. Research function of this instrument during 1982: (CHECK ONE)

|_| 1 Most advanced instrument of its kind that is accessible to those who use it in their research

|_| 2 Used for research; more advanced instruments are available to users when needed

|_| 3 Not used for research during 1982

13. Technical capabilities of this instrument (i.e., the base instrument, excluding accessories) — precision, resolution, speed, volume, etc.: (CHECK ONE)

|_| 1 State-of-the-art (most highly developed and scientifically sophisticated instrument available)

|_| 2 Adequate to meet researcher needs

|_| 3 Inadequate for research (PLEASE EXPLAIN):

_____

_____

_____

14. Technical capabilities of instrument's current accessories (precision, resolution, speed, volume, etc.): (CHECK ONE)

|_| 1 NA - Instrument does not have, and does not need, accessories

|_| 2 State-of-the-art (most highly developed and scientifically sophisticated available)

|_| 3 Adequate to meet researcher needs

|_| 4 Inadequate for research (PLEASE EXPLAIN)

_____

_____

_____

15. In 1982, was this a general purpose instrument within an area of research or was it dedicated for a particular experiment or series of experiments? (CHECK ONE)

|_| 1 General purpose (SKIP TO ITEM 16)

|_| 2 Dedicated

15a. Did this involve any special calibration, programming or other modification which rendered the instrument unsuitable for general purpose use? (CHECK ONE)

|_| 1 Yes

|_| 2 No

16. Approximate number of research investigators who used this instrument (or for whom it was used) for research purposes during 1982: (ESTIMATE APPROXIMATE NUMBER IN EACH APPLICABLE CATEGORY)

_____ 1 Faculty and equivalent nonfaculty researchers, this department/facility

_____ 2 Graduate and postdoctoral students, this department/facility

_____ 3 Faculty and equivalent nonfaculty researchers, other departments, this university

_____ 4 Graduate and postdoctoral students, other departments, this university

_____ 5 Researchers from other universities

_____ 6 Nonacademic researchers

_____ 7 Other (SPECIFY) _____

16a. Instrument's principal area of scientific/engineering research use in 1982 (e.g., physics, astronomy, chemistry, computer science, electrical engineering):

_____

17. Please note in space below: (a) Any additional information needed to clarify the nature, function and quality of this instrument, or (b) any suggestions to improve this questionnaire or its instructions.

18. Person who prepared this submission:

_____ _____

NAME AND TITLE AREA CODE - EXCH - NO - EXT

19. How many person-hours were required to complete this form?

_____ _____

HOURS MINUTES